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IDENTIFIERS	*Aircraft Environmental Systems; Military Curriculum Project

ABSTRACT

This publication contains a teaching guide and student instructional materials for conducting a high school or adult vocational education course to train persons to perform duties as an aircraft environmental systems mechanic. The instructional design for this course is self-paced and/or small group-paced. Instructor materials contained in the course guide include lesson plans detailing training equipment needed, training methods, multiple instructor requirements, and instructional guidance. The student material includes a workbook and programmed texts with review exercises. A bibliography and glossary of terms are provided to aid both teacher and students. The course includes information on organizational and field maintenance of aircraft pressurization, air conditioning, and air starter systems, and life raft inflation equipment. The course is composed of four parts (see note). Block IV (contained in this document) is composed of nine lessons requiring 114.5 hours of instruction. Topics covered are the following: gaseous oxygen systems; liquid oxygen systems; liquid refrigeration systems and components; inspection maintenance of oxygen systems (liquid); cryotainer systems maintenance; liferaft inflation equipment; fire extinguisher system maintenance; flight line maintenance and inspections; and removal and replacement of system components. (KC)

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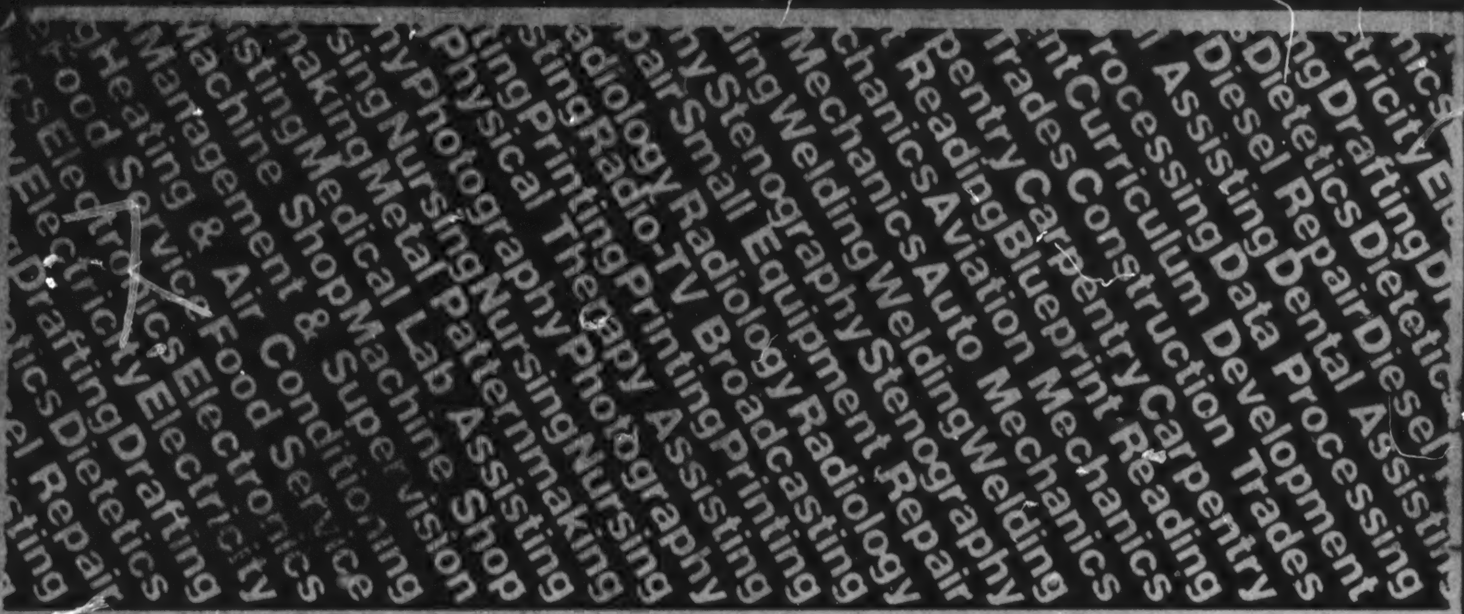

ED212798

Military Curriculum Materials for Vocational and Technical Education

AIRCRAFT ENVIRONMENTAL SYSTEM MECHANIC, 2-9
BLOCK IV - UTILITY SYSTEMS AND
FLIGHT LINE MAINTENANCE

THE NATIONAL CENTER
FOR RESEARCH IN VOCATIONAL EDUCATION
THE OHIO STATE UNIVERSITY
1960 KENNY ROAD · COLUMBUS, OHIO 43210

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MILITARY CURRICULUM MATERIALS

The military-developed curriculum materials in this course package were selected by the National Center for Research in Vocational Education Military Curriculum Project for dissemination to the six regional Curriculum Coordination Centers and other instructional materials agencies. The purpose of disseminating these courses was to make curriculum materials developed by the military more accessible to vocational educators in the civilian setting.

The course materials were acquired, evaluated by project staff and practitioners in the field, and prepared for dissemination. Materials which were specific to the military were deleted, copyrighted materials were either omitted or approval for their use was obtained. These course packages contain curriculum resource materials which can be adapted to support vocational instruction and curriculum development.

The National Center Mission Statement

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Military Curriculum Materials for Vocational and Technical Education

Information and Field
Services Division

The National Center for Research
in Vocational Education

Military Curriculum Materials Dissemination Is . . .

an activity to increase the accessibility of military-developed curriculum materials to vocational and technical educators.

This project, funded by the U.S. Office of Education, includes the identification and acquisition of curriculum materials in print form from the Coast Guard, Air Force, Army, Marine Corps and Navy.

Access to military curriculum materials is provided through a "Joint Memorandum of Understanding" between the U.S. Office of Education and the Department of Defense.

The acquired materials are reviewed by staff and subject matter specialists, and courses deemed applicable to vocational and technical education are selected for dissemination.

The National Center for Research in Vocational Education is the U.S. Office of Education's designated representative to acquire the materials and conduct the project activities.

Project Staff:

Wesley E. Budke, Ph.D., Director
National Center Clearinghouse

Shirley A. Chase, Ph.D.
Project Director

What Materials Are Available?

One hundred twenty courses on microfiche (thirteen in paper form) and descriptions of each have been provided to the vocational Curriculum Coordination Centers and other instructional materials agencies for dissemination.

Course materials include programmed instruction, curriculum outlines, instructor guides, student workbooks and technical manuals.

The 120 courses represent the following sixteen vocational subject areas:

- Agriculture
- Aviation
- Building & Construction Trades
- Clerical Occupations
- Communications
- Drafting
- Electronics
- Engine Mechanics
- Food Service
- Health
- Heating & Air Conditioning
- Machine Shop
- Management & Supervision
- Meteorology & Navigation
- Photography
- Public Service

The number of courses and the subject areas represented will expand as additional materials with application to vocational and technical education are identified and selected for dissemination.

How Can These Materials Be Obtained?

Contact the Curriculum Coordination Center in your region for information on obtaining materials (e.g., availability and cost). They will respond to your request directly or refer you to an instructional materials agency closer to you.

CURRICULUM COORDINATION CENTERS

EAST CENTRAL
Rebecca S. Douglass
Director
100 North First Street
Springfield, IL 62777
217/782-0759

MIDWEST
Robert Patton
Director
1515 West Sixth Ave.
Stillwater, OK 74704
405/377-2000

NORTHEAST
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Trenton, NJ 08625
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Olympia, WA 98504
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SOUTHEAST
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Mississippi State, MS 39762
601/325-2510

WESTERN
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1776 University Ave.
Honolulu, HI 96822
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AIRCRAFT ENVIRONMENTAL SYSTEM MECHANIC
3ABR42331

Classroom Course 2-9

Developed by:
United States Air Force

Development and Review Dates:
October 17, 1978

Occupational Area:
Aviation

Target Audiences:
Grades 11 - adult

Print Pages:
3122

Availability:
ERIC
National Center Clearinghouse

Contents:	Type of Materials:						Instructional Design:				Type of Instruction:	
	Lesson Plans:	Programmed Text:	Student Workbook:	Handouts:	Text Materials:	Audio-Visuals:	Performance Objectives:	Tests:	Review Exercises:	Additional Materials Required:	Group Instruction:	Individualized:
Block I -												
Fundamentals	•	•	•		•		•		•		•	•
Block II -												
Air Conditioning Systems	•	•	•		•	X	•		•		•	•
Block III - Aircraft Environmental Systems Units	•	•	•		•	X	•		•	X	•	•
* Block IV - Utility Systems and Flight Line Maintenance	•	•		•	•	X	•		•	X	•	•

X Materials are recommended but not provided.

Course Description

The instructional design for this course is self-paced and/or small group paced. This course trains personnel to perform duties as an Aircraft Environmental Systems Mechanic. It includes organizational and field maintenance of aircraft pressurization, air conditioning, and air starter systems, and life raft inflation equipment.

Block I - Fundamentals contains 24 lessons requiring 115 hours of instruction. These are: safety; aircraft familiarization; physics; electron theory; magnetism; DC generation and basic circuit symbols and terms; wiring diagram fundamentals; control and protective devices; multimeter; Kirchoff's current law; Kirchoff's voltage law; Ohm's law; series circuits; parallel circuits; series-parallel circuits; switching circuits; DC motors and control circuit; temperature control circuits; alternating current; capacitance; inductance; AC motors and control circuits; solid state devices; magnetic amplifiers; and trainer aircraft air conditioning system.

Block II - Air Conditioning Systems consists of 8 lessons convering 124 hours of instruction. These are: fighter cabin air conditioning system; rain removal system; equipment air conditioning system; temperature control system tester; bomber air conditioning system; decade resistor functions and windshield amplifier bench check; cargo bleed air and anti-icing system; and cargo air conditioning system.

Block III - Aircraft Environmental Systems Units contains 13 lessons covering 102 hours of instruction. These are the following: tools, hardware, safetying devices, and wire repair; maintenance of moisture separators; maintenance of bleed air distribution ducting; air turbine motor maintenance; turbine refrigeration devices; advanced fighter/bomber air source control system; advanced fighter/bomber air conditioning system; advanced fighter/bomber windshield clearing system; maintenance of air control units; anti-G suit system; canopy seal system; pressurization systems; and cabin pressure leakage check.

Block IV - Utility Systems and Flight Line Maintenance consists of 9 lessons requiring 114.5 hours of instruction. These lessons are entitled: gaseous O_2 systems; liquid O_2 systems; liquid refrigeration systems and components; inspection maintenance of O_2 systems (liquid); cryotainer systems maintenance; liferaft inflation equipment, fire extinguisher system maintenance; flight line maintenance - inspections; and flight line maintenance; removal and replacement of system components.

This course contains both teacher and student materials. Printed instructor materials include plans of instruction detailing training equipment needed, training methods, multiple instructor requirements and instructional guidance. The student material includes workbook, and programmed texts with review exercises. A bibliography and glossary of terms have been provided to aid both the instructor and the student. In Blocks I and III, lessons on Orientation, Security, Progression in Career Field, Maintenance Management, and the Technical Order Publications Systems have been deleted because of military specific materials.

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PROGRAMMED TEXT
3ABR42331-PT-401

Technical Training

Aircraft Environmental Systems Mechanic

PRINCIPLES OF GASEOUS OXYGEN AND SAFETY

12 January 1979

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

2629

FOREWORD

This programmed text was prepared for use in the 3ABR42331 instructional system. The materials contained herein have been validated using students enrolled in the 3ABR42331 course. Ninety percent of the students taking this text have either achieved or surpassed the criteria called for in the lesson objective. The average student required 1.5 hours to complete this text.

OBJECTIVES

To help you understand the operation of the components and the necessity of the oxygen system, this programmed text covers the physiological effects of an oxygen deficiency. In addition, safety in handling oxygen equipment is also covered. You will be required to accomplish the following objectives.

1. Select without error, safety precautions pertaining to the use and handling of gaseous oxygen.

INSTRUCTIONS

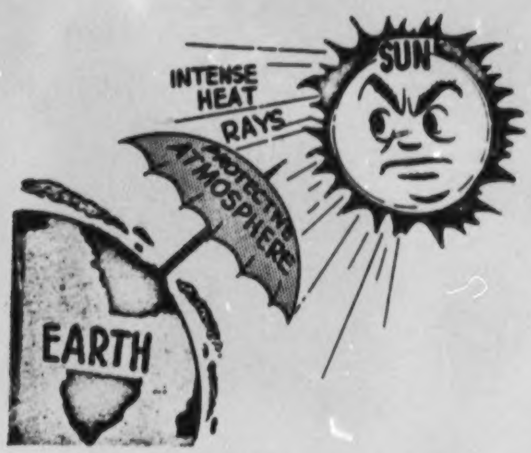
This programmed text presents material in small steps called "frames." After each frame you will find a number of statements and you are asked to select the statement/s that are true. Read the material in each frame before making a selection. The answers to each frame can be found at the top of the next page. If you select the correct answers, continue to the next frame. If you are wrong or in doubt, read the material again and correct yourself before continuing.

Supersedes 3ABR42331-PT-401, 25 August 1977.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 600; TTVSA - 1

2630

Frame 1

As the earth turns on its axis and goes in a path around the sun, it is forever accompanied by a gaseous sea of air called "atmosphere." Man lives at the bottom of this sea. Raise him a few miles from the bottom and he suffers from internal pressures, becomes unconscious or dies. Man can live many days with no food, a few days with no water, but only a few minutes with no air. The atmosphere, a mixture of gases, is made up of 21% oxygen, 78% nitrogen, and 1% other gases. The percentage of this composition of air does not change with altitude, however, its density decreases fast with altitude. The air gets "thin" because less pressure is applied as altitude increases.



Canopy of Atmosphere.

Check the following statement/s that are true.

_____1. Without air, a man can live only a few minutes.

_____2. Twenty-one percent of the atmosphere is oxygen.

_____3. As altitude increases, pressure increases.

_____4. The same composition of air is present at any altitude.

_____5. Air gets thin at higher altitudes because less pressure is applied to it.

2631

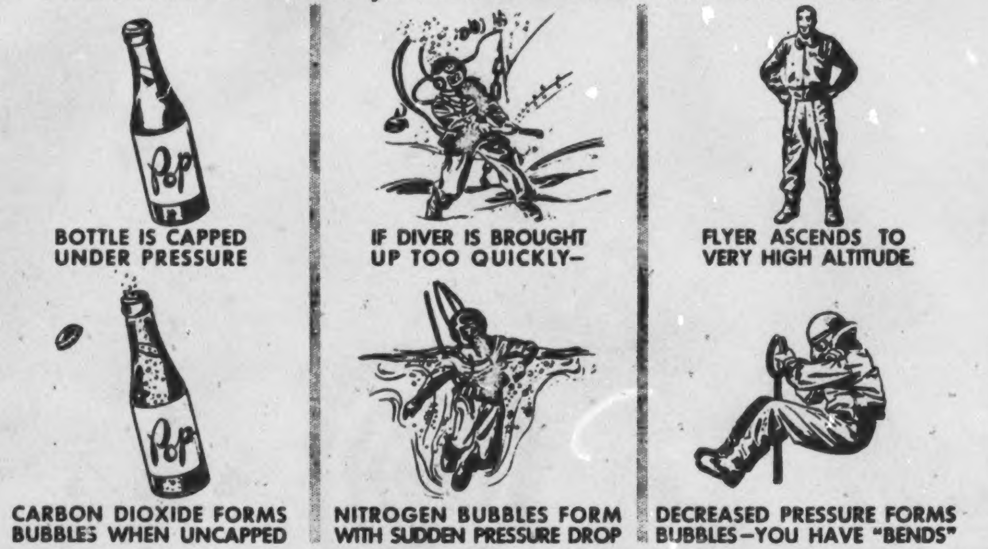
Answers to Frame 1: ✓ 1. ✓ 2. ____ 3. ✓ 4. ✓ 5.

Frame 2

Since man can not live in the "thin" air at high altitude, the aircraft cabin is pressurized to as near sea level as it can be. This lets man go a little higher but not high enough. Changes in pressure have an important effect on humans, and at higher altitudes a loss of pressure can cause the "bends." Oxygen equipment must be used to stop this from happening. Also think of what would happen if pressurization was lost. We know that oxygen is required at higher altitudes in order to live. The type of oxygen aviators need must be free of the other elements found in the air we breathe on earth, such as dust, moisture, etc.

"BENDS" **pain from too great a pressure decrease—nitrogen bubbles form in your blood and body fluids**

A BOTTLE OF SODA, A DEEP-SEA DIVER AND YOU!


Pop
BOTTLE IS CAPPED UNDER PRESSURE
IF DIVER IS BROUGHT UP TOO QUICKLY—
FLYER ASCENDS TO VERY HIGH ALTITUDE
Pop
CARBON DIOXIDE FORMS BUBBLES WHEN UNCAPPED
NITROGEN BUBBLES FORM WITH SUDDEN PRESSURE DROP
DECREASED PRESSURE FORMS BUBBLES—YOU HAVE "BENDS"

Complete the following statements by filling in the proper word.

1. At high altitudes a sudden drop in cabin pressure can cause ______________.

2. If cabin pressurization was lost at high altitudes the flight crew would need ______________ to survive.

3. Temperature and ______________ constantly change during flight.

Answers to Frame 2: 1. bends 2. oxygen 3. pressure

Frame 3

Oxygen is one of the most abundant substances in the world. As previously stated, 21% of the air we breathe is oxygen. In its free state, oxygen is a gas with no odor, color, or taste but is very active chemically and will combine with nearly all other elements. Atoms of free oxygen usually combine in twos to form molecules, with the chemical symbol O_2. Oxygen is not combustible but will readily support combustion.

Gaseous oxygen can be changed to a liquid by a process of compression and expansion.

Check the following statement/s that are true.

_____1. Twenty-one percent of the atmosphere is oxygen.

_____2. The chemical symbol for gaseous oxygen molecule is O_2.

_____3. One oxygen atom usually makes an oxygen molecule.

_____4. Oxygen is a gas that is odorless, colorless, and tasteless.

_____5. Oxygen will not support combustion.

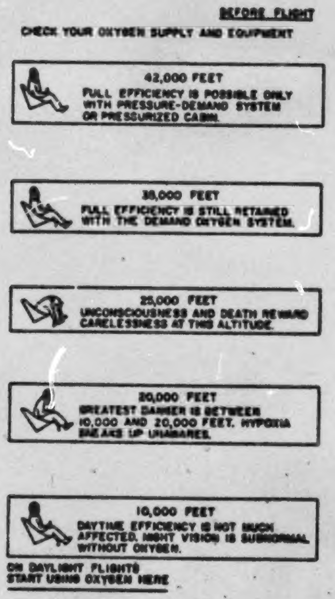
_____6. Gaseous oxygen can be turned into a liquid.

2633

Answers to Frame 3: _✓_1. _✓_2. ____3. _✓_4. ____5. _✓_6.

Frame 4

When too much of a loss of oxygen occurs in the human body and the body tissue is permanently damaged, a person is said to be suffering from anoxia. Anoxia is the absence of oxygen in the right quantity. This condition could be caused by an oxygen system that fails or some other gas that took the place of the oxygen in a closed in area. With no oxygen, the human body stops its work in a few seconds. As an environmental systems mechanic it will be your job to make sure that the oxygen system is doing its job right. See the sketch for the basic rules in using oxygen.


BEFORE FLIGHT
CHECK YOUR OXYGEN SUPPLY AND EQUIPMENT
42,000 FEET
FULL EFFICIENCY IS POSSIBLE ONLY WITH PRESSURE-DEMAND SYSTEM OR PRESSURIZED CABIN.
35,000 FEET
FULL EFFICIENCY IS STILL RETAINED WITH THE DEMAND OXYGEN SYSTEM.
25,000 FEET
UNCONSCIOUSNESS AND DEATH REWARD CARELESSNESS AT THIS ALTITUDE.
20,000 FEET
GREATEST DANGER IS BETWEEN 10,000 AND 20,000 FEET. HYPOXIA SNEAKS UP UNAWARES.
10,000 FEET
DAYTIME EFFICIENCY IS NOT MUCH AFFECTED. NIGHT VISION IS SUBNORMAL WITHOUT OXYGEN.
ON DAYLIGHT FLIGHTS
START USING OXYGEN HERE

AT NIGHT USE OXYGEN
FROM THE GROUND UP

Refer to the illustration above to complete the following statements.

1. Without oxygen, unconsciousness and death will occur at ________ feet.

2. Without oxygen, day time efficiency is not affected but night vision is subnormal at _____ feet.

3. A pressure-demand oxygen system is needed to operate at full efficiency at _____ feet.

2634

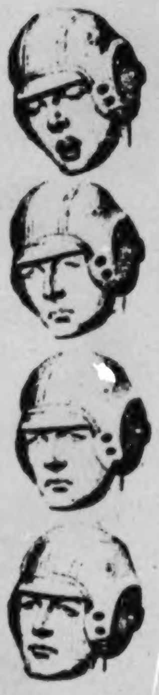
Answers to Frame 4: 1. 25,000 feet 2. 10,000 feet 3. 42,000 feet

Frame 5

We determined that anoxia was permanent damage as a result of inadequate oxygenation of the blood. Hypoxia is not enough oxygen in the blood stream. To work normally, the body needs a well balanced supply of oxygen all of the time. Hypoxia has various effects on the human body at different altitudes (see chart). Hypoxia is dangerous because it creeps up on a person without his knowing it. If a pilot does not know the signs of hypoxia, he will either crash the aircraft or die from being starved for oxygen.

symptoms of HYPOXIA!

35 to 40 THOUSAND FEET	15 to 45 SEC'S.	IMMEDIATE UNCONSCIOUSNESS! (with little or no warning!)
20 to 25 THOUSAND FEET	5 MIN'S.	SAME SYMPTOMS AS "15 to 18" ONLY MORE PRONOUNCED WITH EVENTUAL UNCONSCIOUSNESS
15 to 18 THOUSAND FEET	½ HOUR	IMPAIRMENT OF JUDGMENT AND VISION, HIGH SELF CONFIDENCE DISREGARD FOR SENSORY PERCEPTIONS, POOR COORDINATION, SLEEPINESS, DIZZINESS, PERSONALITY CHANGES–AS IN A MILD DRUNK–CYANOSIS (BLUING)
10 to 14 THOUSAND FEET	HOURS	HEADACHE, FATIGUE, RESTLESSNESS



Check the following statement/s that are true.

_____1. Hypoxia is a deficiency of oxygen in the blood.

_____2. The symptoms of hypoxia cannot be recognized.

_____3. At 35 to 40,000 feet, unconsciousness occurs with little or no warning.

_____4. The body requires a balanced supply of oxygen.

2635

Answers to Frame 5: _✓_1. ____2. _✓_3. _✓_4.

Frame 6

With anoxia and hypoxia we found the body to be with no oxygen or a deficiency in oxygen. Going in the opposite direction, we find that hyperventilation is breathing too much which produces too much oxygen in the body leading to an abnormal loss of carbon dioxide from the blood. The extreme signs of hyperventilation are muscular contractions and complete loss of body control. A person's body gets stiff and he will "freeze." An example of hyperventilation would be a man who is running a foot race. When he stops he will feel dizzy, be breathing deeply and his body will be partially out of control. A pilot may experience hyperventilation from getting excited in an emergency or from an attack by enemy aircraft. It is possible that he will "freeze" at the controls and crash. As a rule, hyperventilation is not serious and will pass in a few minutes.

Check the following statement/s that are true.

_____1. Hyperventilation is overbreathing.

_____2. Hyperventilation will kill in seconds like anoxia.

_____3. It's possible for a pilot to "freeze" at the controls from hyperventilation.

_____4. Normally, hyperventilation is not serious and will pass.

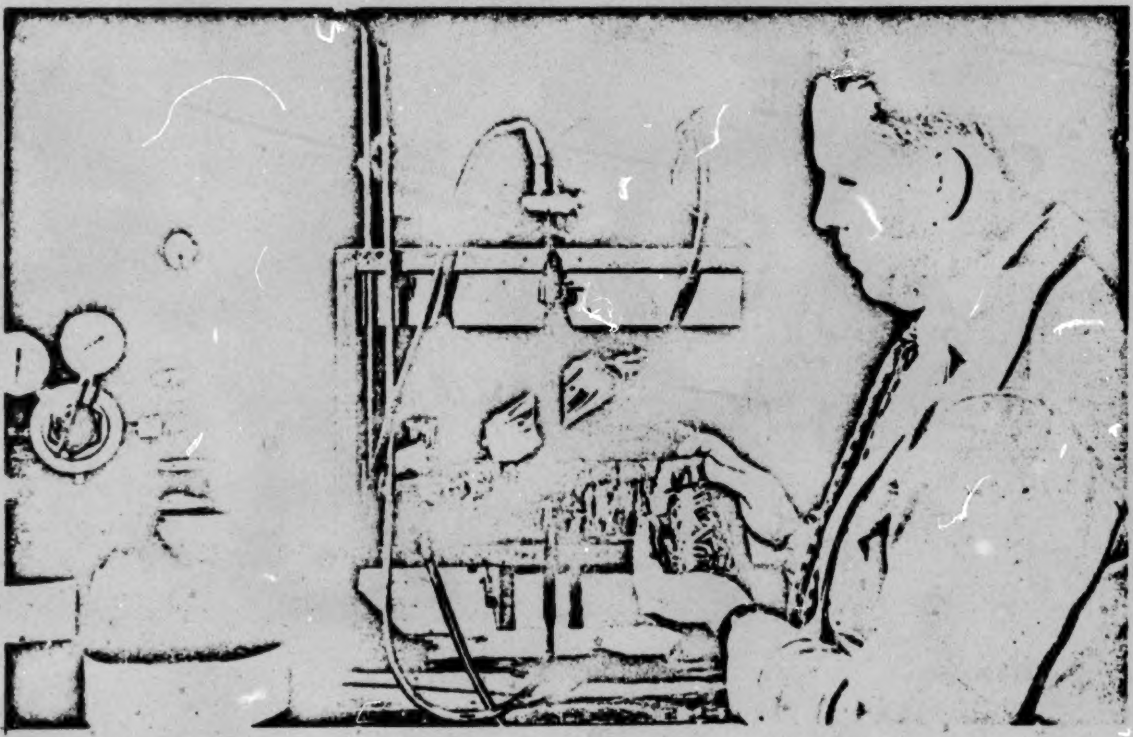
_____5. Hyperventilation is the opposite of anoxia.

2636

Answers to Frame 6: ✓ 1. ____2. ✓ 3. ✓ 4. ✓ 5.

Frame 7

Aviators' breathing oxygen is made through a process called "distillation," where moisture and other impurities are taken out of the air as it is warmed and cooled. Moisture is especially harmful to oxygen systems because it will freeze at 32 degrees F and all valves and regulators are then useless. Aviators' oxygen is refined until it is 99.5% moisture free. Do not substitute this with any other oxygen. Oxygen made for hospital use is only 98% moisture free and welding oxygen is about 70% moisture free.



Testing Oxygen in Cylinder to Assure 99.5% Purity.

Complete the following statements by filling in the proper word.

1. Aviators' oxygen is ____% moisture free.

2. Moisture will, at 32°F, ________ in the oxygen system components.

3. Aviators' oxygen is produced through a process called ____________________.

4. Hospital oxygen is only _____% moisture free.

2637

Answers to Frame 7: 1. 99.5 2. freeze 3. distillation 4. 98

Frame 8

In the preceding frames we covered the physiological effects of oxygen deficiency. Let's review this information now. Circle the letter of the answer that is correct for each of the following statements.

1. Man can live only a few minutes with no

   a. air.
   b. food.
   c. water.

2. The atmosphere is

   a. 78% oxygen.
   b. 78% other gases.
   c. 28% oxygen.
   d. 28% other gases.

3. At high altitudes a sudden drop in pressure can cause

   a. anoxia.
   b. hypoxia.
   c. bends.

4. At 10,000 feet night vision is subnormal without

   a. nitrogen.
   b. oxygen.

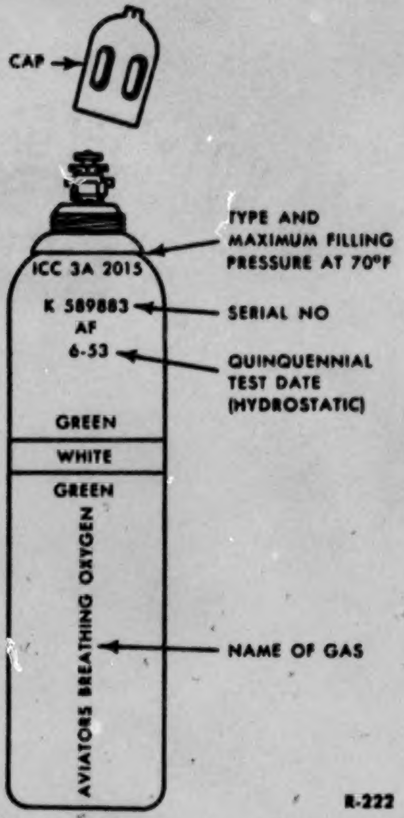
5. A deficiency of oxygen in the blood is called

   a. anoxia.
   b. hypoxia.
   c. hyperventilation.

Answers to Frame 8: 1. a 2. c 3. c 4. b 5. b

Frame 9

Gaseous oxygen is stored under high pressure in cylinders made of steel with no seams. They measure 8 1/2 inches by 51 inches. To determine the difference in aviators breathing oxygen from other gases, the cylinders are painted a dark green color with a 3 inch band of white near the valve end. To further identify these cylinders the words "AVIATORS BREATHING OXYGEN" are stenciled on the cylinder in block letters. All of these methods of identification are for one purpose: to make sure that no other gas is put in an oxygen system.


CAP
TYPE AND MAXIMUM FILLING PRESSURE AT 70°F
ICC 3A 2015
K 589883
AF
6-53
SERIAL NO
QUINQUENNIAL TEST DATE (HYDROSTATIC)
GREEN
WHITE
GREEN
AVIATORS BREATHING OXYGEN
NAME OF GAS
R-222

Check the following statement/s that are true.

_____1. To distinguish aviators' oxygen from other gases, the cylinders are painted green.

_____2. Gaseous oxygen is stored under high pressure.

_____3. A 3-inch white band is painted around the bottom of each cylinder.

2639

Frame 9 (Continued)

_____4. The words AVIATORS BREATHING OXYGEN is stenciled on each cylinder.

_____5. All cylinder identification is to make sure that no other gas is put in an oxygen system.

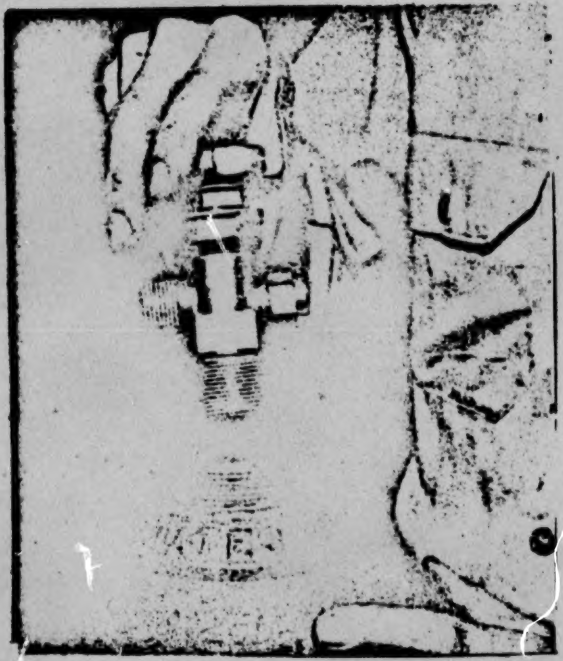
_____6. Gaseous oxygen cylinders are made of seamless steel.

2640

Answers to Frame 9: ✓ 1. ✓ 2. ___ 3. ✓ 4. ✓ 5. ✓ 6.

Frame 10

As said before, the gaseous oxygen cylinder is made of steel with no seams. The control valve on the cylinder is hand wheel operated and the outlets are set at 90 degree angles to the cylinders (see below). This is to stop the rocket action of the cylinder if the valve should be opened accidentally or if the rupture disc (safety disc) blows out. The rupture disc is a thin piece of gold plated steel which will not corrode and become weak. The disc is designed to blow out if thermal expansion raises the cylinder pressure above 2200 psi. The valve outlet threads are designed so that other gas cylinders cannot be connected to oxygen recharging equipment. The type of gas (oxygen) the valve was designed for is stamped on the side of the valve. A metal cap is screwed on over the valve during handling or shipment to protect it (see cap in frame 8). Never use oil or grease on oxygen valves or fittings.



2641

Frame 10 (Continued)

Select, by placing a checkmark in the blank, those items that are safety factors.

_____1. To prevent rocketing, the valve outlets are at 90° angles to the cylinder.

_____2. The oxygen valve contains a gold plated rupture disc.

_____3. Other gas cylinders can be connected to oxygen recharging equipment.

_____4. The rupture disc is designed to take care of thermal expansion in the cylinder.

Answers to Frame 10: ✓ 1. ✓ 2. ____ 3. ✓ 4.

2642

Frame 11

The Interstate Commerce Commission (ICC) requires that all high pressure compressed gas cylinders be given a hydrostatic test once in every five years (quinquennially). The test pressure used must be 5/3 times the working pressure of the cylinder. Maximum service pressure for oxygen storage cylinders is 2015 psi; therefore the cylinders are subjected to a total pressure of 3400 psi. This test is made up of water being forced under high pressure in the cylinders to stretch it slightly. The cylinder being tested is put in water and the water displaced by the expansion is marked. When the pressure is let out the water level should go back to the starting point. If it does not, the cylinder has stretched permanently and must be rejected. The test date is stamped on the neck of the cylinder (see frame 9).

Check the following statement/s that are true.

____ 1. A hydrostatic test is performed on all high pressure compressed gas cylinders quinquennially.

____ 2. During the hydrostatic test the water level of the water tank should go back to the starting level when the pressure in the gas cylinder is released.

____ 3. The hydrostatic test pressure used in a compressed gas cylinder must be 5/3 times the working pressure of the cylinder.

2643

Answers to Frame 11: ✓ 1. ✓ 2. ✓ 3.

Frame 12

While you are in the Air Force, you will be going to a number of safety briefings, lectures, and movies to point out the hazards and safety precautions you should take while working on the flight line. The Air Force spends a lot of man-hours each month to make you "think" safety. In your job, you will be working with oxygen which requires that you use safety each and every day on all jobs. In the following frames safety precautions peculiar to gaseous oxygen will be covered. You will be required to know these safety precautions so you can select them from a list of safety precautions without any error. You must be able to apply them without looking them up.

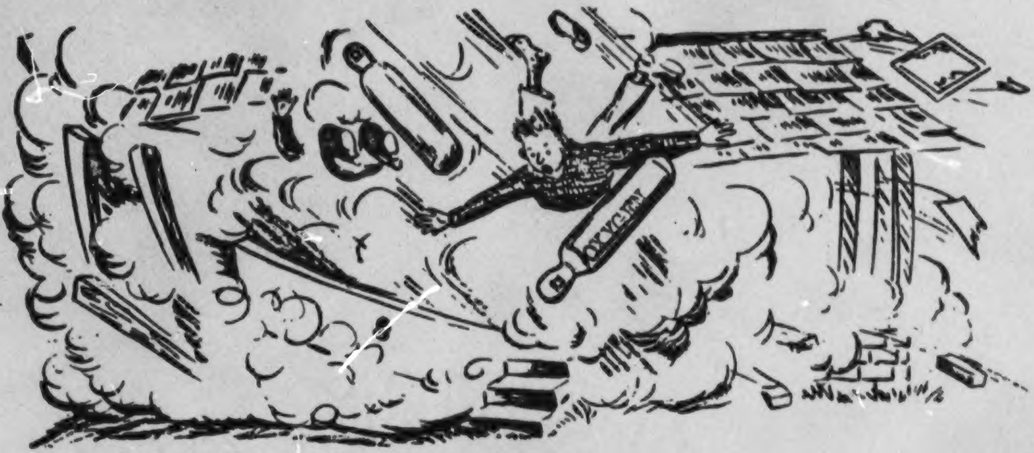
SAFETY PRECAUTIONS

NO RESPONSE REQUIRED

Frame 13

One of the most important safety rules that you should know about oxygen is that it makes other materials burn very fast. In other words, it supports combustion. This characteristic, in addition to the fact that oxygen is handled under pressure in excess of 2000 psi, gives just cause for strict adherence to all safety rules. This text will go over some of the basic rules.

The area where oxygen cylinders are stored should be well ventilated to prevent a harmful accumulation or explosive concentration of gas.



This is Not a Bomb Explosion.

Check the following statement/s that are true.

______1. Oxygen makes other materials burn rapidly.

______2. High pressure gas of any kind is a hazard.

______3. Oxygen should not be allowed to accumulate in a confined area.

______4. Oxygen itself does not burn but supports combustion.

Answers to Frame 13: ✓ 1. ✓ 2. ✓ 3. ✓ 4.

Frame 14

When storing oxygen cylinders, they should be protected from extreme temperatures. They should at no time be stored closer than 50 feet to highly flammable materials. Oxygen cylinders should also be kept from all other gases in storage. Explosions and fires have been the result of mistaking oxygen for other gases that are used for fuel cell purging, putting air in tires, etc. So remember, never mix oxygen with petroleum base products; "you may not be here to tell about it."

Check the safety precautions.

______ 1. Oxygen cylinders should be protected from high temperatures.

______ 2. Oxygen and petroleum base products must not be mixed.

______ 3. Oxygen and other gases should be separated during storage.

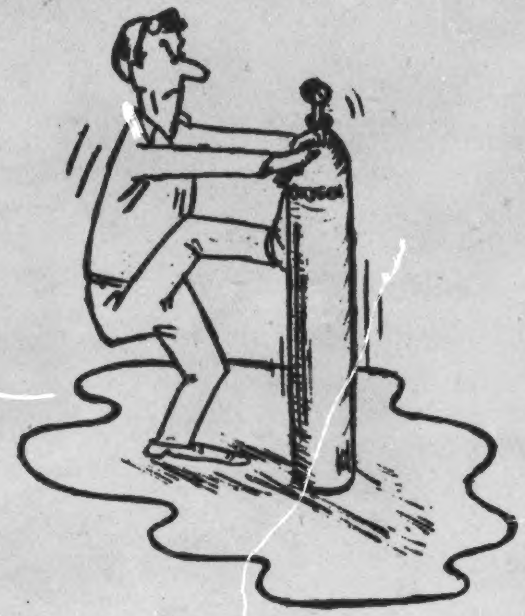
______ 4. Oxygen should be stored at least 50 feet from flammable materials.

______ 5. Oxygen can be mistaken for other gases.

Answers to Frame 14: ✓ 1. ✓ 2. ✓ 3. ✓ 4. ✓ 5.

Frame 15

▲ Oxygen cylinders should be handled with care. If the cylinder control valve is accidentally broken off, the cylinder will become a "rocket." Damaged cylinders are also subject to explosion. Do not open the control valve with the outlet pointing at you or anyone else because the high pressure gas will cut your skin or destroy your eyesight. It is also possible to rupture the internal organs of your body if oxygen is directed into the mouth or ears. The hand wheel on the valve should be operated by hand only.



Check the safety precautions.

____ 1. All oxygen cylinders should be handled with care.

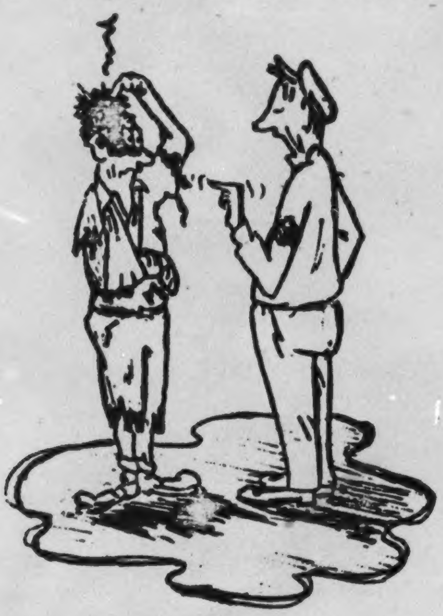
____ 2. When opening the cylinder control valve, it should be pointed away from you.

2647

Answers to Frame 15: ✓ 1. ✓ 2.

Frame 16

When working near oxygen, all tools, clothes, and equipment must be kept free of grease and oil. Spontaneous combustion may take place when oil and oxygen mix. More dangerous than spontaneous combustion is the use of oxygen near a fire or equipment that will make a spark. Smoking near an oxygen area is a sure way to get blown up. Do not smoke right after being in an oxygen area or after servicing an aircraft because your clothes may have some oxygen trapped in them. Allow a few minutes for your clothes to air out.



Check the safety precautions.

____ 1. Smoking in an oxygen area is a dangerous practice.

____ 2. When working around oxygen, clothes, tools, and equipment must be free of oil and grease.

Answers to Frame 16: ✓ 1. ✓ 2.

Frame 17

Let's review some of the safety precautions that were covered in the past three frames. If you did not answer this frame correctly go back and reread the past three frames. In safety there is no room for error.

Check the gaseous oxygen safety precautions.

_____1. Oxygen cylinders should be handled with care.

_____2. Wear the correct protective clothing (face shield, neoprene apron, non-absorbent gloves) when handling the oxygen cylinders.

_____3. Oxygen cylinders should be protected against high temperatures.

_____4. Do not smoke where oxygen is being used.

_____5. Select the proper tool for the job.

_____6. Do not mix oxygen with petroleum base products.

_____7. Oxygen should be stored at least 50 feet from flammable materials.

_____8. The control valve of an oxygen cylinder should be pointed away from you when it is opened.

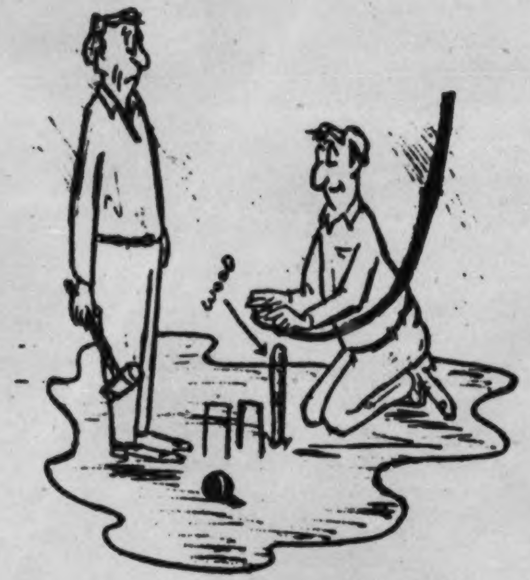
_____9. Proper ear protection must be worn when servicing the aircraft.

2649

Answers to Frame 17: __✓__ 1. _____ 2. __✓__ 3. __✓__ 4. _____ 5. __✓__ 6.
__✓__ 7. __✓__ 8. _____ 9.

Frame 18

Before servicing an aircraft with oxygen, it should be "grounded." Aircraft build up static electricity during flight and could cause a spark when touched with the oxygen equipment. A proper ground wire will eliminate this. No power should be on the aircraft during servicing and the external power unit should be moved out of the area.



Check the oxygen safety precautions.

_____1. The aircraft should be grounded before it is serviced with oxygen.

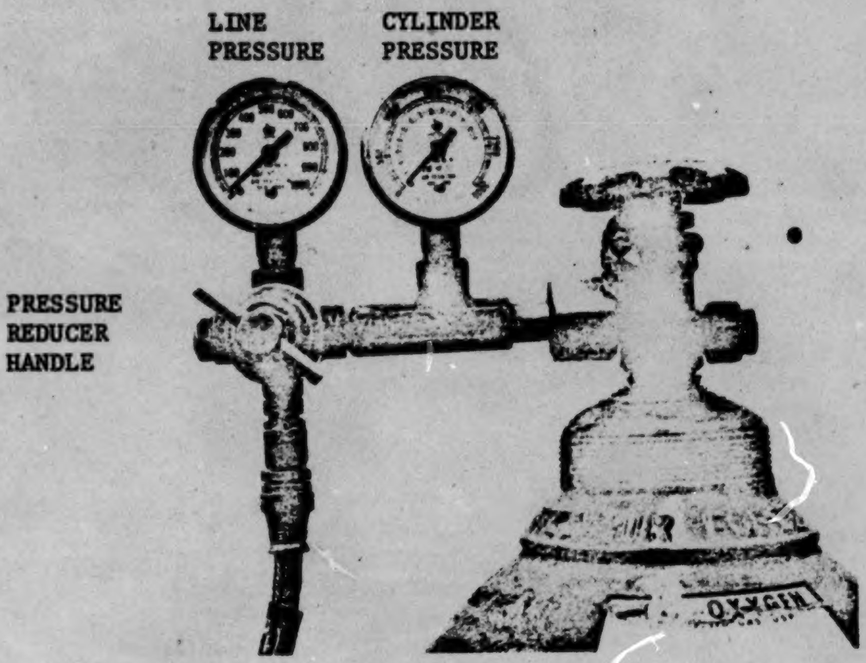
_____2. When servicing the aircraft with gaseous oxygen, wear protective clothing.

_____3. No power should be on the aircraft during servicing.

Answers to Frame 18: ✓ 1. ____ 2. ✓ 3.

Frame 19

As previously stated, oxygen is stored in cylinders under high pressure. Most gaseous oxygen systems are low pressure systems (450 PSI). In this case, a pressure reducer will have to be used (see illustration). This will prevent the high pressure from exploding the aircraft cylinders. The pressure reducer is part of the low pressure servicing cart and should always be used.


LINE PRESSURE
CYLINDER PRESSURE
PRESSURE REDUCER HANDLE
OXYGEN

Check the oxygen safety precautions.

____ 1. A pressure reducer is required when servicing a low pressure oxygen system.

____ 2. Low pressure gaseous oxygen pressure is 650 psi.

2651

Answers to Frame 19: ✓ 1. ____2.

Frame 20

Oxygen is a harmless gas if handled correctly. Do not take any short cuts that eliminate a safety rule just to get the job done. You should respect a dangerous item because you recognize its ability to destroy, and not just because somebody said it was dangerous. Remember, with oxygen the safe way is the best way.

Now check your understanding of the safety precautions involved with gaseous oxygen. Remember if you miss any of these items you should go back to frame 13, restudy each frame, then check yourself again. In safety there is no room for error.

Check the oxygen safety precautions.

____1. Do not smoke where oxygen is being used.

____2. Oxygen cylinders should be protected against high temperature.

____3. Oxygen cylinders should be handled with care.

____4. Trichloroethylene should be used outdoors or in a well ventilated building.

____5. Combustible trash must be placed in closed metal containers.

____6. Do not mix oxygen with petroleum base products.

____7. The safe distance behind an operating jet engine is 200 feet.

____8. Oxygen cylinders should be stored at least 50 feet from flammable materials.

____9. The aircraft should be grounded before it is serviced with oxygen.

____10. The control valve of an oxygen cylinder should always be pointed away from you when it is opened.

____11. Ear protectors should be worn whenever the aircraft is serviced with gaseous oxygen.

____12. No power should be on the aircraft while servicing with gaseous oxygen.

____13. Protective clothing (face shield, rubber apron, non-absorbent gloves) must be worn when servicing the aircraft with gaseous oxygen.

____14. A pressure reducer must be used when servicing a low pressure oxygen system.

____15. The safe distance in front of an operating jet engine intake is 25 feet.

2652

Answers to Frame 20: ✓ 1. ✓ 2. ✓ 3. ____ 4. ____ 5.

✓ 6. ____ 7. ✓ 8. ✓ 9. ✓ 10.

____ 11. ✓ 12. ____ 13. ✓ 14. ____ 15.

2653

PREPARE THE MAN

PROGRAMMED TEXT
3ABR42331-PT-401A

Technical Training

Aircraft Environmental Systems Mechanic

LOW AND HIGH-PRESSURE GASEOUS OXYGEN SYSTEMS

10 February 1976

USAF SCHOOL OF APPLIED AEROSPACE SCIENCES
3370th Technical Training Group
Chanute Air Force Base, Illinois

Designed For ATC Course Use

DO NOT USE ON THE JOB

2654

FOREWORD

This programmed text was prepared for use in the 3ABR42231 Instructional System. The material contained herein has been validated using 36 42010 students enrolled in the 3ABR42231 course. Ninety percent of the students taking this text surpassed the criteria called for in the approved lesson objective. The average student required 45 minutes to complete the text.

OBJECTIVES

After completing this programmed text, you will be able to:

1. Explain the principles of operation of low-pressure oxygen systems.

2. Describe pressure and flow indicators used in low-pressure oxygen systems.

3. Explain the principles of operation of high-pressure oxygen systems.

4. Describe pressure and flow indicators used in high-pressure oxygen systems.

INSTRUCTIONS

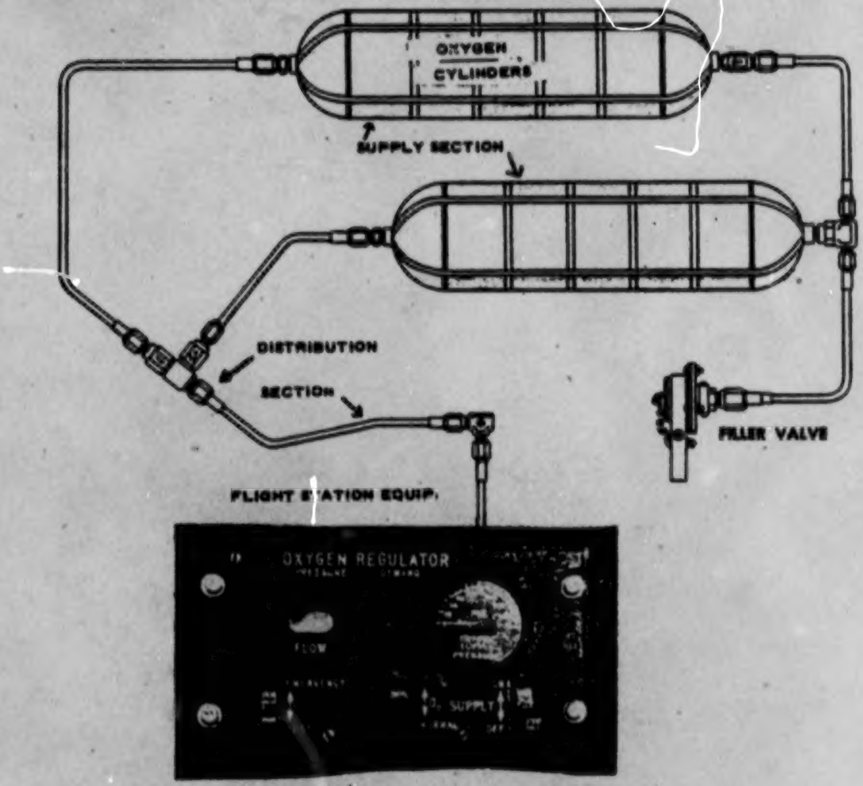
This programmed text presents material in small steps called "frames." After each step you are asked to select the correct statement or match some statements. Read the material presented and make your response as directed in the frame. The correct answer to each frame can be found on the top of the next page. If your answer is correct proceed to the next frame; if you are wrong or in doubt, read the material again and correct yourself before continuing.

Supersedes 3ABR42231-PT-401A, 18 September 1972.
OPR: TAS
DISTRIBUTION: X
TAS - 150; TTVGC - 1

2655

Frame 1

Many types of oxygen systems are used on aircraft. A system consists of two sections: the supply or storage section with its connecting plumbing, and the distribution section which includes the regulators. The type of system used in a given aircraft is determined by the type of regulator that is used. Oxygen regulators are grouped into three types: demand, pressure demand, and continuous flow. Any of the three types of regulators can be used with any type of supply system. The types of supply systems are low and high pressure gaseous oxygen, and low and high pressure liquid oxygen.


OXYGEN
CYLINDERS
SUPPLY SECTION
DISTRIBUTION
SECTION
FILLER VALVE
FLIGHT STATION EQUIP.
OXYGEN REGULATOR
FLOW
SUPPLY

Check the following statement/s that are true.

_____1. The type of oxygen system is determined by the regulator used.

_____2. Any of the three types of regulators can be used with any of the supply systems.

_____3. Normally there are five sections in an oxygen system.

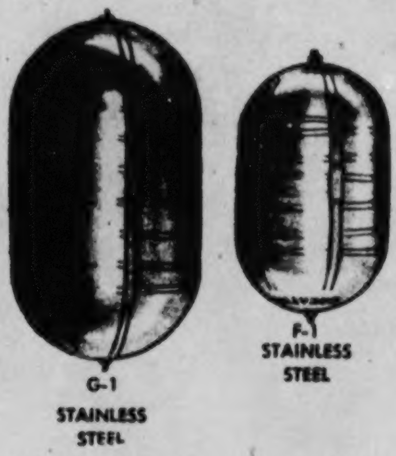
_____4. The three types of regulators are demand, pressure demand, and continuous flow.

2656

Answers to Frame 1: ✓ 1. ✓ 2. ___3. ✓ 4.

Frame 2

The low pressure gaseous oxygen system is used on the old type transport and cargo aircraft. The cylinders are mounted with straps in sections of the aircraft where space is available. They carry a maximum charge of 450 psi and are considered to be full between 400 and 450 psi. The pressure should not be allowed to drop below 50 psi. This is to prevent contamination of the cylinder due to moisture that will accumulate in the cylinder. Low pressure cylinders are made shatterproof by welding metal bands to the outer side. The cylinders are made of stainless steel or a low alloy steel and are painted yellow to identify them as low pressure.



Typical Low-Pressure Cylinders (Painted Yellow)

Check the following statement/s that are true.

___1. All low pressure cylinders are painted yellow.

___2. Maximum service pressure for low pressure cylinders is 450 psi.

___3. At least 50 psi should always be left in the cylinders.

___4. Low pressure cylinders are not shatterproof.

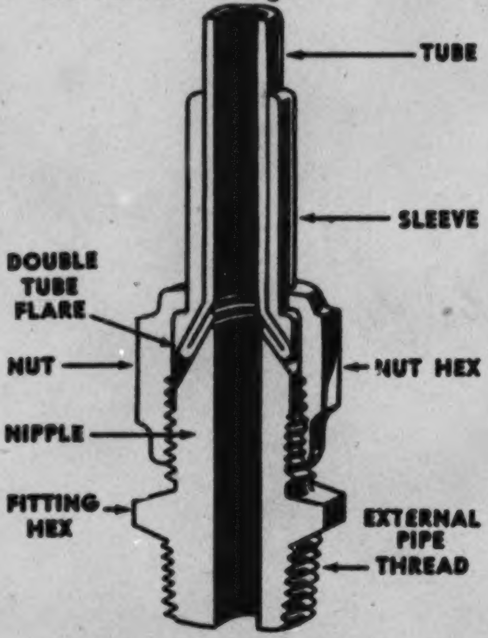
___5. Low pressure cylinders are considered full at 400 psi.

Answers to Frame 2: ✓ 1. ✓ 2. ✓ 3. ____4. ✓ 5.

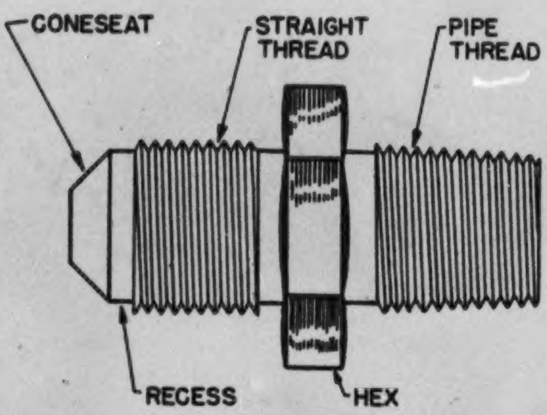
Frame 3

Low pressure systems use 5/16-inch aluminum tubing. The tubing used in all oxygen systems has the size numbered in 1/16-inch increments. A number 5 tubing has an outer diameter of 5/16-inch, a number 3 would be 3/16-inch, etc. All tubing carrying oxygen is color coded with green tape to distinguish it from other tubing in the aircraft. During manufacture the tubing used is heat treated for strength and treated also to prevent corrosion. Two kinds of connections are used in oxygen systems: flared tube connections, and pipe thread connections.

The fittings used in low pressure systems are made of aluminum alloy and painted blue to identify the material. These are "AN" standard (Army-Navy) fittings. The pipe thread end of the fitting screws into cylinders, regulators, and gages. The coneseat end connects the flared tubing.


TUBE
SLEEVE
DOUBLE TUBE FLARE
NUT
NUT HEX
NIPPLE
FITTING HEX
EXTERNAL PIPE THREAD

Double Flared Connection


CONESEAT
STRAIGHT THREAD
PIPE THREAD
RECESS
HEX

AN Standard Fitting (Painted Blue)

Check the following statement/s that are true.

_____1. If you asked for a piece of number 5 tubing, you would get 5/16.

_____2. Low pressure systems use number 5 aluminum tubing.

_____3. The flared tubing is connected to the pipe thread fitting.

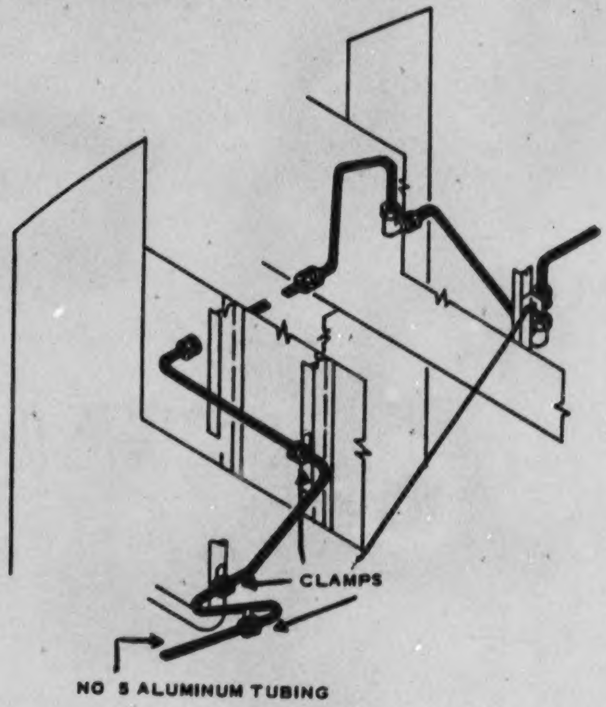
_____4. All tubing carrying oxygen is color coded green.

2658

Answers to Frame 3: ___✓___1. ___✓___2. ___✓___3. ___✓___4.

Frame 4

The tubing is braced with clamps every 15 inches apart and at each bend all through the aircraft. This helps to reduce tubing vibration and also helps to prevent chafing of the tubing. Oxygen tubing should be installed with at least a two-inch clearance between electrical wiring or any control cables. The tubing is bent when necessary to insure that this clearance is maintained. The tubing may run within 1/2-inch of electrical wiring so long as more insulation is used on the wires, but this is the absolute minimum.



Check the following statement/s that are true.

_____1. Tubing should be clamped every 15 inches and at each bend.

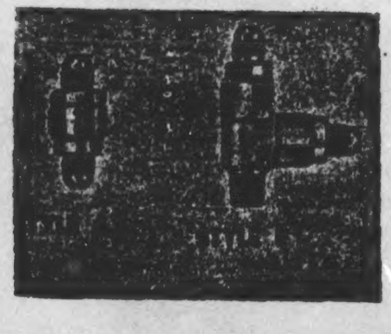
_____2. A two-inch clearance should be maintained between tubing and electrical wires and control cables.

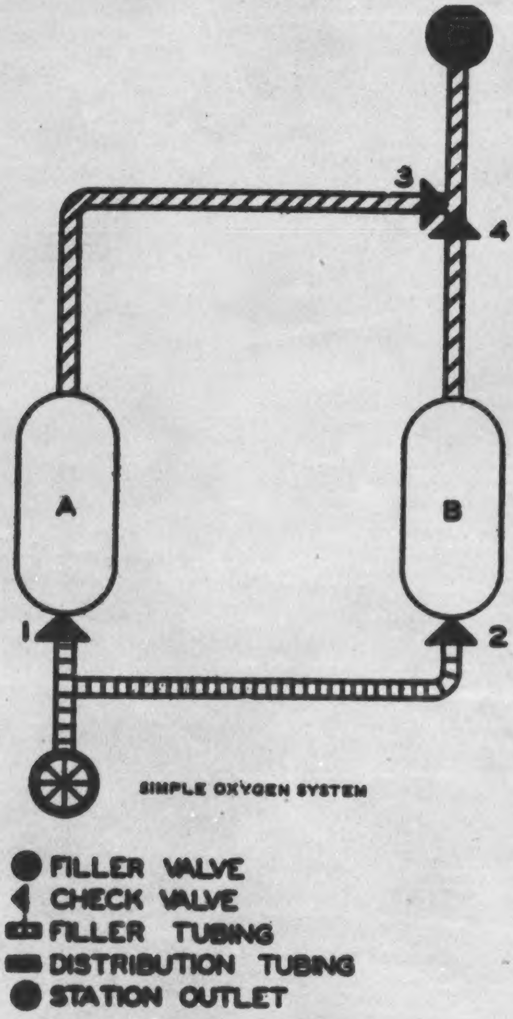
_____3. 1/2-inch is the absolute minimum clearance on oxygen tubing.

Answers to Frame 4: ✓ 1. ✓ 2. ✓ 3.

Frame 5

Check valves are used in oxygen systems that have more than one cylinder. A check valve helps to prevent a complete loss of oxygen if part of the system is damaged. Check valves may be in many styles to meet the need of the installation. An arrow on the side of the check valve shows the direction of free flow. If cylinder "A", in the illustration, ruptured, the oxygen in cylinder "B" would not go out through the hole because of check valve number 3. Check valves must be installed so that all cylinders can be filled from a single filler valve, all cylinders will feed the regulator, and if one cylinder ruptures, the other cylinders will not drain out through it.




3
4
A
B
1
2
SIMPLE OXYGEN SYSTEM
● FILLER VALVE
CHECK VALVE
FILLER TUBING
DISTRIBUTION TUBING
● STATION OUTLET

Check the following statement/s that are true.

_____1. The arrow on a check valve indicates direction of free flow.

_____2. Check valves are not required if more than one cylinder is used.

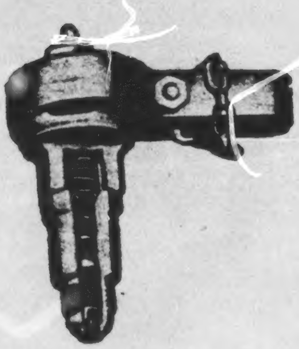
_____3. Check valves are installed so that all cylinders can be filled from one valve.

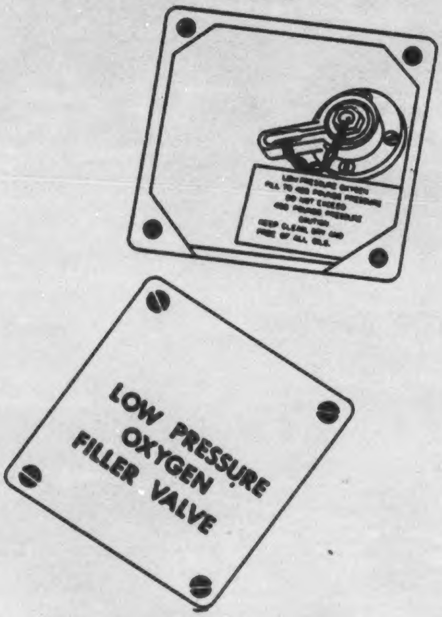
2660

Answers to Frame 5: ✓ 1. ____2. ✓ 3.

Frame 6

Filler valves are used when filling the oxygen system. They are usually mounted near the outer surface of the aircraft in a recessed well and under an access cover. Each filler valve has a dust plug attached to the valve by a chain. The plug can be removed by turning the handle. When the dust plug is removed, a recharge adapter on the servicing hose is put in the filler valve to fill the system. The filler valve is nothing more than a spring loaded check valve that is unseated by the recharge adapter and seats when the adapter is removed.





Check the following statement/s that are true.

____1. A filler valve is a spring loaded check valve.

____2. The recharge adapter unseats the filler valve.

____3. The filler valve is located on the outer surface of the aircraft.

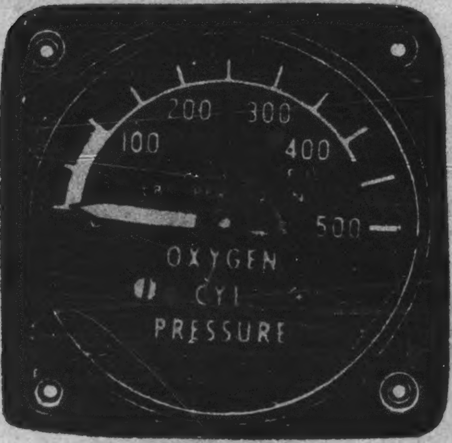
____4. A wrench is required to connect the recharge adapter.

2661

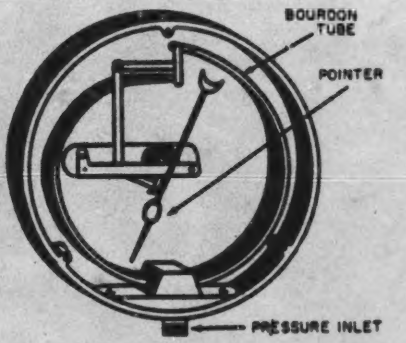
Answers to Frame 6: ✓ 1. ✓ 2. ✓ 3. ____ 4.

Frame 7

A separate gage may be used in some low pressure oxygen systems to show cylinder or system pressure. This will depend on the type of regulator that is used. Some regulators have a pressure gage built in them. One of the indicators used is the K-1 bourdon tube-operated type. The bourdon tube is hollow and in the shape of a "C." Pressure put on the inside of the tube will try to straighten it out. The pointer is linked through levers to the bourdon tube. The dial face is marked off in 50 psi graduations and the 0-100 psi range is lined out to attract attention to these pressure readings. Most gages have a red mark on the glass cover at 450 psi to point out the maximum service pressure. The gage is found in the cockpit in a readily visible location.



K-1 Pressure Gage



Check the following statement/s that are true.

____ 1. The K-1 pressure gage is bourdon tube-operated.

____ 2. Some regulators have a pressure gage built in.

____ 3. The K-1 pressure gage is electrically operated.

____ 4. The pointer is connected through levers to the bourdon tube.

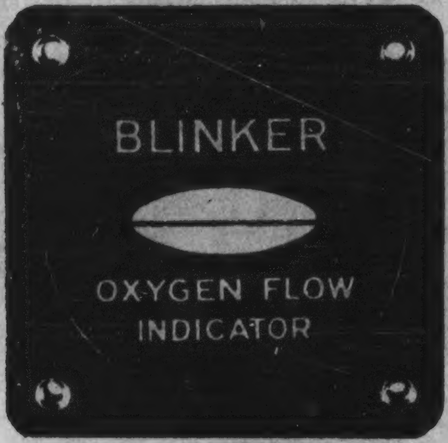
____ 5. Pressure in the hollow bourdon tube tends to straighten it out and deflects the needle.

2662

Answers to Frame 7: _✓_1. _✓_2. ____3. _✓_4. _✓_5.

Frame 8

A separate flow indicator is used in some low pressure oxygen systems to show that oxygen is flowing through the regulator. Some regulators have a flow indicator built in them. The A-3 flow indicator is the type used as a separate flow indicator. The A-3 indicates by a blinking action when the user inhales through the oxygen mask. The blinker "eye" is actuated by a diaphragm in the unit. The flow indicator does not show how much oxygen is flowing or that the user is getting enough oxygen, it just tells the user that he is receiving a flow.



A-3 Flow Indicator

Check the following statement/s that are true.

_____1. The A-3 indicates oxygen flow through the regulator.

_____2. "Blinker" is the correct name for the A-3.

_____3. The blinker eye operates from a diaphragm.

_____4. Some regulators have a built in flow indicator.

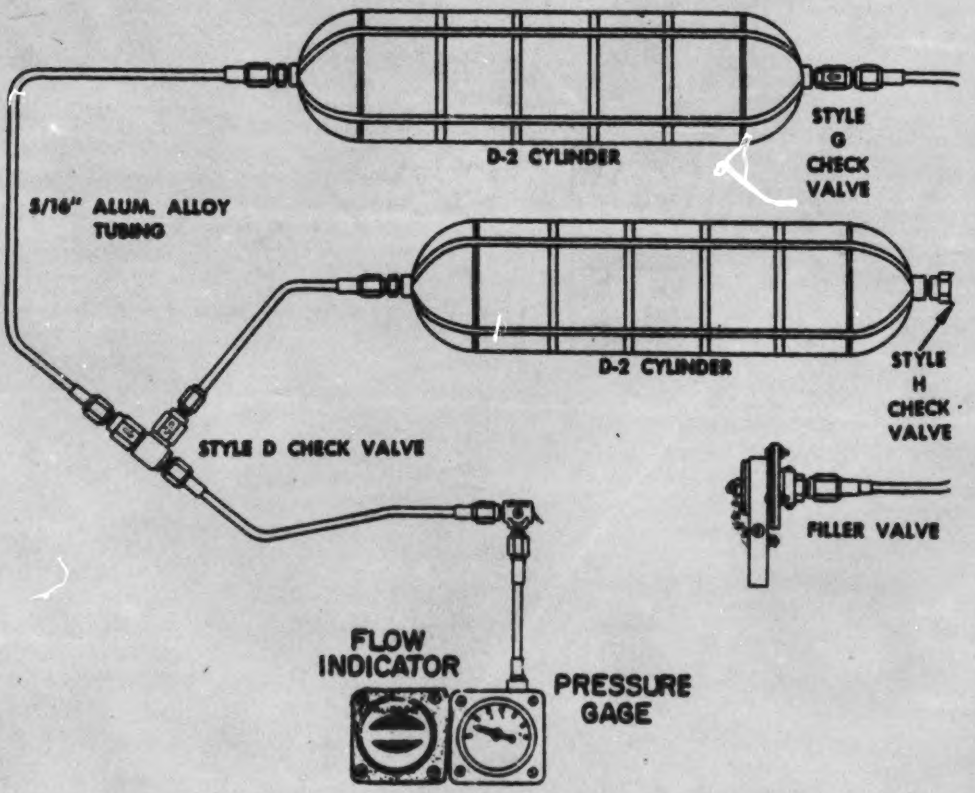
_____5. The A-3 does not indicate the amount of oxygen flowing.

2663

Answers to Frame 8: ✓ 1. ___ 2. ✓ 3. ✓ 4. ✓ 5.

Frame 9

Shown is a low pressure oxygen system with all the units that have been covered in the text. This system uses the D-2 shatterproof cylinder, various style check valves, number 5 aluminum tubing, low pressure filler valve, flow indicator, and pressure gage. The size and amount of cylinders used depends upon the need of the particular aircraft that the system is used on.


D-2 CYLINDER
STYLE G CHECK VALVE
5/16" ALUM. ALLOY TUBING
D-2 CYLINDER
STYLE H CHECK VALVE
STYLE D CHECK VALVE
FILLER VALVE
FLOW INDICATOR
PRESSURE GAGE

NO RESPONSE REQUIRED

2664

Answer to Frame 9: None Required.

Frame 10

The high pressure oxygen system has the same principle of operation as the low pressure system. Its one advantage is that more oxygen can be stored in a smaller space; however, the oxygen is stored at a high pressure (1,800 psi). The same maintenance procedures and safety rules apply to both the high and low pressure oxygen systems. Care must be taken when opening lines in a high pressure system. Make sure they have been drained to prevent possible body damage from the high pressure. High pressure gaseous oxygen systems are not widely used, but they will be your responsibility.

Check the following statement/s that are true.

_____1. More oxygen can be stored in a smaller space using a high pressure system.

_____2. High pressure oxygen is particularly dangerous.

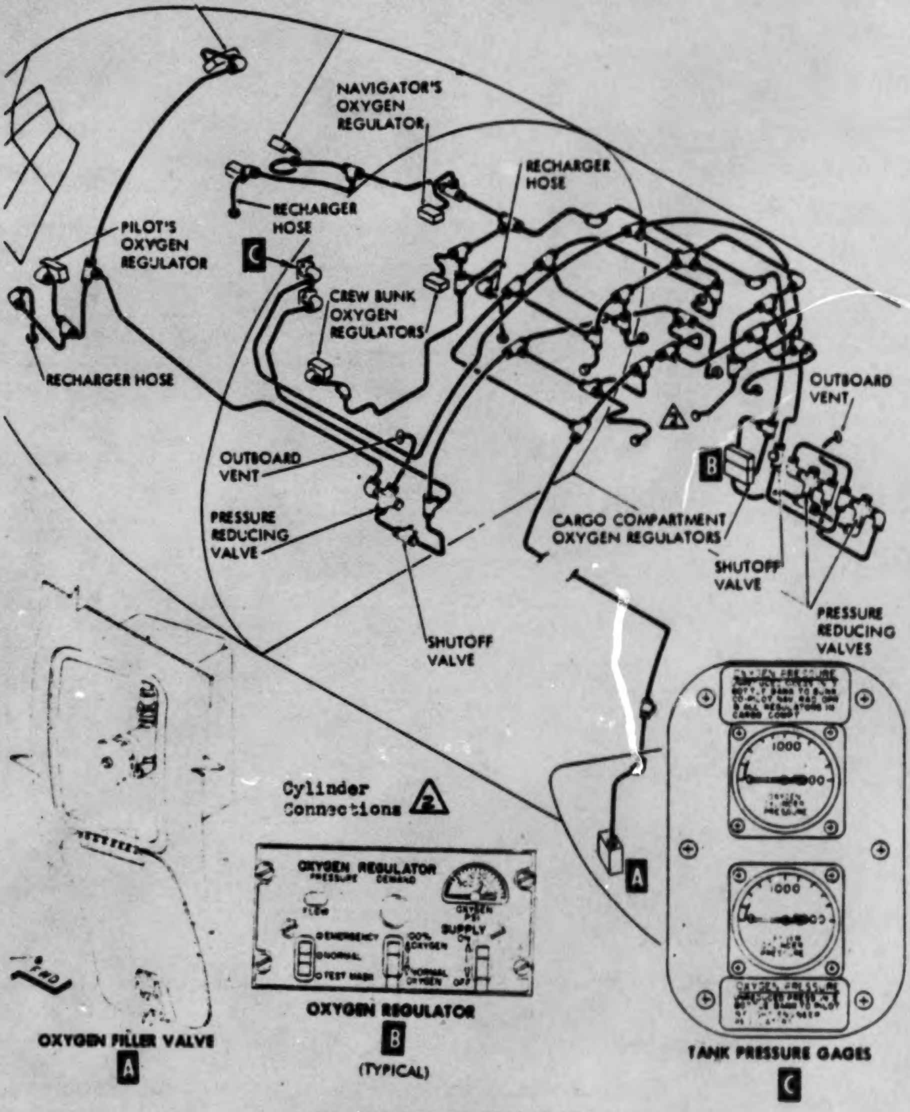
_____3. High pressure oxygen systems are widely used.

_____4. In general, the same safety precautions apply to low and high pressure systems.

Answers to Frame 10: ✓ 1. ✓ 2. ____3. ✓ 4.

Frame 11

Find these listed units in the illustration shown: the high pressure filler valve, the pressure reducing valves, the system shutoff valves, the pressure gages, and the cylinder connection points. The check valves, which are not shown, are the next items in the plumbing. These items and the plumbing will be covered in this text.


NAVIGATOR'S OXYGEN REGULATOR
RECHARGER HOSE
RECHARGER HOSE
PILOT'S OXYGEN REGULATOR
C
CREW BUNK OXYGEN REGULATORS
RECHARGER HOSE
OUTBOARD VENT
2
B
OUTBOARD VENT
PRESSURE REDUCING VALVE
CARGO COMPARTMENT OXYGEN REGULATORS
SHUTOFF VALVE
SHUTOFF VALVE
PRESSURE REDUCING VALVES
Cylinder Connections 2
A
OXYGEN REGULATOR
PRESSURE DEMAND
FLOW
EMERGENCY
NORMAL
TEST MASK
100% OXYGEN
NORMAL OXYGEN
SUPPLY
ON
OFF
OXYGEN PSI
1000
1000
OXYGEN FILLER VALVE
A
OXYGEN REGULATOR
B
(TYPICAL)
TANK PRESSURE GAGES
C

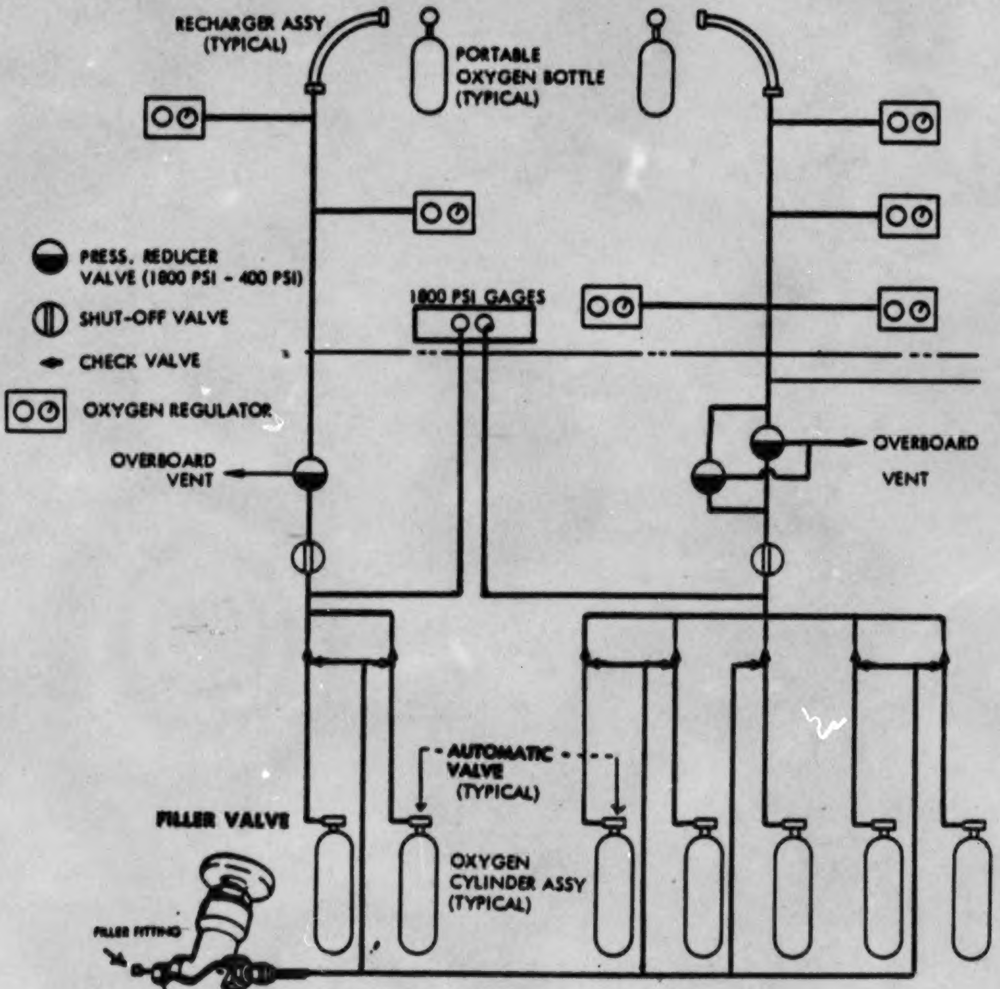
NO RESPONSE REQUIRED

2666

Answer to Frame 11: None Required.

Frame 12

Study this simplified diagram of the same system that was given in the last frame. Note the two separate systems. The two cylinders shown on the lift side of the system supply the oxygen to the regulators on that side. The left side has its own system shutoff valve pressure reducer valve, and cylinder pressure gage. The right side has two pressure reducing valves that are hooked in parallel. The cylinders for both sides are filled from a common filler valve.


RECHARGER ASSY (TYPICAL)
PORTABLE OXYGEN BOTTLE (TYPICAL)
PRESS. REDUCER VALVE (1800 PSI - 400 PSI)
SHUT-OFF VALVE
CHECK VALVE
OXYGEN REGULATOR
1800 PSI GAGES
OVERBOARD VENT
OVERBOARD VENT
AUTOMATIC VALVE (TYPICAL)
FILLER VALVE
FILLER FITTING
OXYGEN CYLINDER ASSY (TYPICAL)

Check the following statement/s that are true.

_____1. In the schematic shown, there are two separate high pressure systems.

_____2. All cylinders are filled from a common filler valve.

_____3. The components are completely different in each system.

_____4. The right hand side has two pressure reducing valves in parallel.

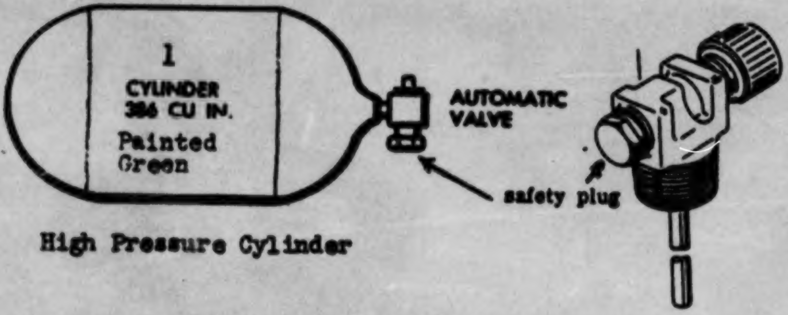
48

2667

Answers to Frame 12: ✓ 1. ✓ 2. ____ 3. ✓ 4.

Frame 13

The high pressure oxygen cylinders are made of forged seamless steel and are wire-wrapped to make them shatterproof. The service pressure for the cylinders is from 1,800 to 1,850 psi. These high pressure cylinders are painted green. An automatic valve is put on the release end of the cylinder to let the cylinder be removed without discharging, for maintenance on the system. A fusible safety plug is in the automatic valve to dump pressure if the temperature gets between 208° and 220°F. A hydrostatic test is required on these high pressure cylinders every five years to determine their condition. The test date is stamped on the neck of the cylinder.



High Pressure Cylinder

Check the following statement/s that are true.

____1. 1,850 psi would be the maximum service pressure.

____2. High pressure cylinders are wire-wrapped to make them shatterproof.

____3. All high pressure cylinders are painted green.

____4. The automatic valve allows the cylinder to be removed without discharging.

____5. A fusible plug is built into the automatic valve.

____6. The high pressure cylinders are made of aluminum.

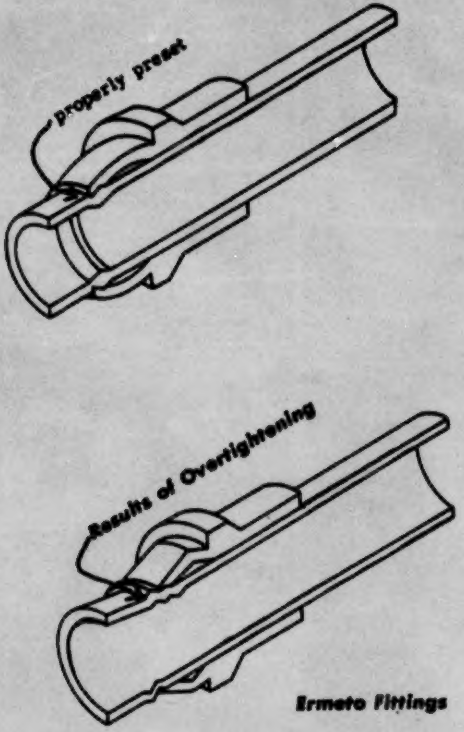
____7. The fusible safety plug will melt at a temperature of 208° to 220°F.

2668

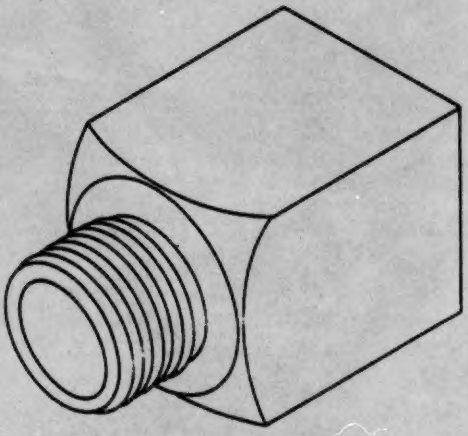
Answers to Frame 13: ✓ 1. ✓ 2. ✓ 3. ✓ 4. ✓ 5.
____ 6. ✓ 7.

Frame 14

The tubing used in high pressure gaseous oxygen systems is either 3/16-inch or 5/16-inch stainless steel. Aluminum tubing will not stand the high pressure. The high pressure stainless steel tubing requires a flareless type fitting called Ermeto fitting. The fitting consists of a sleeve which is preset on the end of the tubing before the tubing is put in a flareless seat. If you overtighten an Ermeto fitting while trying to stop a leak, it usually will leak more. A torque wrench should always be used.



Ermeto Fittings



Hand Presetting Tool

Check the following statement/s that are true.

____1. High pressure systems use stainless steel tubing.

____2. Ermeto fittings are flareless fittings.

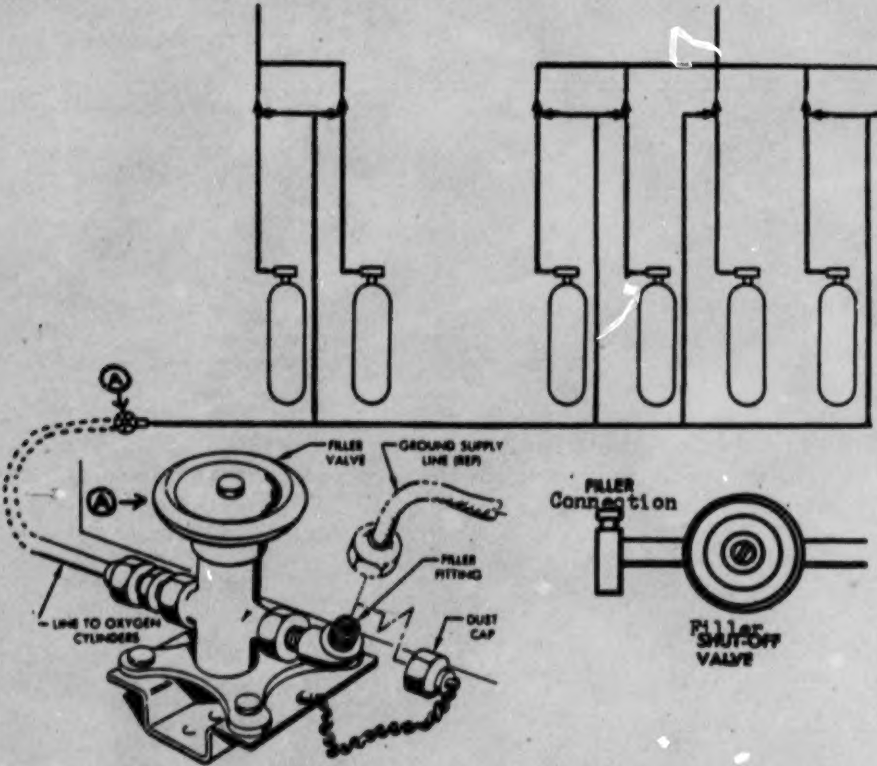
____3. You can stop an Ermeto fitting from leaking by increasing the torque.

____4. A torque wrench should always be used on an Ermeto fitting.

Answers to Frame 14: ✓ 1. ✓ 2. ____3. ✓ 4.

Frame 15

The high pressure filler valve is hand wheel operated and separates the filler connection from the cylinders. This valve must be open when the system is filled with oxygen and is closed at all other times. The filler connection is used to hook the rcharging equipment to the aircraft system. The type of filler valve connection shown in one illustration is flange mounted to the aircraft and in the other it is part of the valve. Because of the high pressure used quick disconnects are not used when the system is recharged. The system check valves serve the same purpose as in the low pressure oxygen system, but are made to stand higher pressures. Remember, check valves stop a reverse flow.


A
FILLER VALVE
GROUND SUPPLY LINE (REF)
A
FILLER FITTING
LINE TO OXYGEN CYLINDERS
DUST CAP
FILLER Connection
Filler SHUT-OFF VALVE

Check the following statement/s that are true.

____1. The filler valve is opened only for filling the system.

____2. Quick disconnects are used when recharging high pressure systems.

____3. The filler valve separates the filler connection and cylinders.

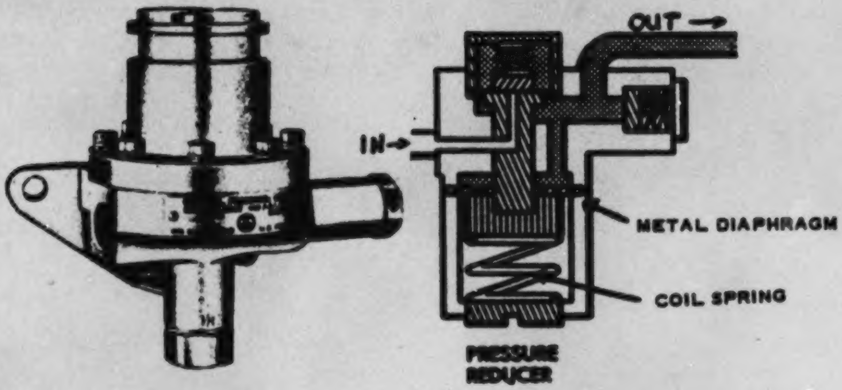
____4. The check valves are used to prevent reverse flow.

2670

Answers to Frame 15: _✓_ 1. ____ 2. _✓_ 3. _✓_ 4.

Frame 16

A separate pressure reducing valve is used in high pressure oxygen systems to drop the cylinder pressure from 1,800 psi to 300 to 400 psi before it goes in the regulator. This valve has a relief section that vents the pressure overboard if the reducing section fails to work. This is a safety feature to stop the regulators from rupturing if the valve fails to work. The major parts are a metal diaphragm and a coil spring assembly.



Check the following statement/s that are true.

____ 1. The pressure reducer drops the cylinder pressure from 1,800 psi to between 300 to 400 psi.

____ 2. If the pressure reducing valve malfunctions and the relief valve vents the pressure overboard, the regulator will rupture.

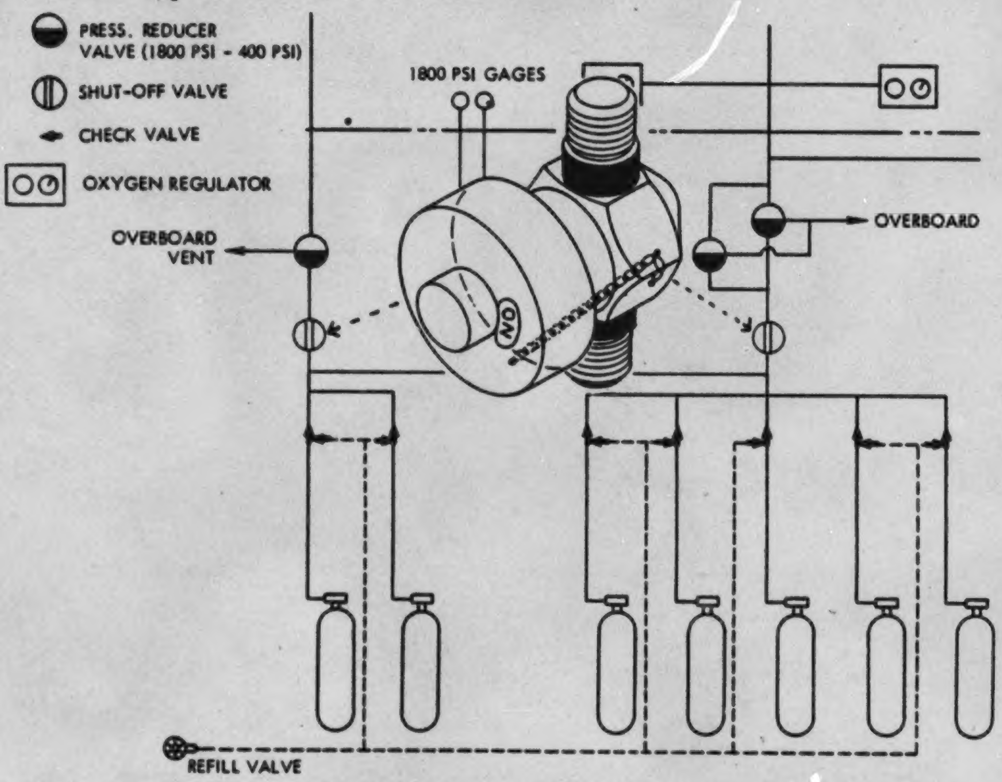
____ 3. The major parts of a pressure reducer valve are a metal diaphragm and a coil spring assembly.

____ 4. The pressure reducer valve contains a relief section.

Answers to Frame 16: ✓ 1. _____ 2. ✓ 3. ✓ 4.

Frame 17

The system shutoff valve used in the high pressure oxygen system is placed between the cylinders and the pressure reducing valve. This is a manual hand wheel operated valve that is normally safety-wired to the open position. In case of an emergency this valve can be closed to isolate the distribution system from the cylinders. It can also be used when maintenance is done on the system. The valve should always be left in the open position and safety-wired. The position that the shutoff valve is in (on or off) can be seen through a window in the top of the control knob.


PRESS. REDUCER VALVE (1800 PSI - 400 PSI)
SHUT-OFF VALVE
CHECK VALVE
OXYGEN REGULATOR
1800 PSI GAGES
OVERBOARD
OVERBOARD VENT
ON
REFILL VALVE

Check the following statement/s that are true.

_____ 1. The system shutoff valve is hand wheel operated.

_____ 2. The shutoff valve is always closed.

_____ 3. The shutoff valve is located between the cylinders and pressure reducing valve.

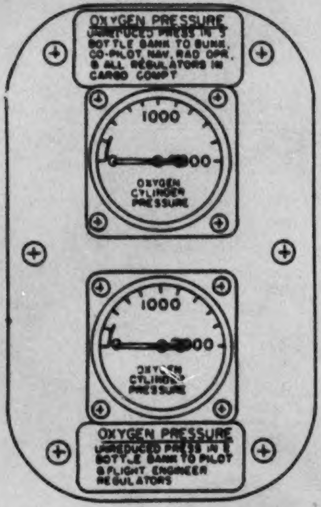
_____ 4. The valve is normally in the open position and safety-wired.

2672

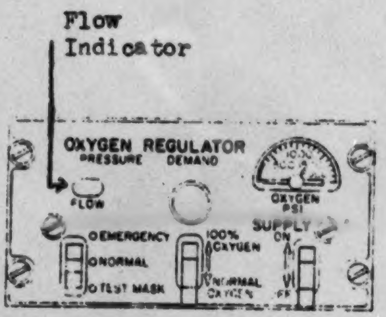
Answers to Frame 17: ✓ 1. ____2. ✓ 3. ✓ 4.

Frame 18

A pressure gage is used to show cylinder pressure. Some aircraft have two systems and both pressure gages are shown. Keep in mind that this is cylinder pressure and not reduced pressure. The gage is tapped into the syteem before the pressure reducing valve. The gage is bourdon tube operated and reads from 0 to 2,000 psi, with increments of 200 psi marked off on the dial. The regulator that is used on the C-130 aircraft has a flow indicator built in to let the user know that oxygen is flowing through the regulator. When the user takes a breath of oxygen, a "flag" attached to a diaphragm shows through a glass window on the face of the regulator.


OXYGEN PRESSURE
UNREDUCED PRESS IN 3 BOTTLE BANK TO BUNK, CO-PILOT NAV. RAD OPR. & ALL REGULATORS IN CARGO COMPT
1000
2000
OXYGEN CYLINDER PRESSURE
1000
2000
OXYGEN CYLINDER PRESSURE
OXYGEN PRESSURE
UNREDUCED PRESS IN 2 BOTTLE BANK TO PILOT & FLIGHT ENGINEER REGULATORS

TANK PRESSURE GAGES


Flow Indicator
OXYGEN REGULATOR
PRESSURE DEMAND
FLOW
OXYGEN PSI
SUPPLY
ON
EMERGENCY
NORMAL
TEST MASK
100% OXYGEN
NORMAL OXYGEN

OXYGEN REGULATOR

Check the following statement/s that are true.

____1. The pressure gage indicates cylinder pressure.

____2. The diagram above shows two separate pressure gages.

____3. The flow indicator on the C-130 is part of the regulator.

____4. The flow indicator on the C-130 is the A-3.

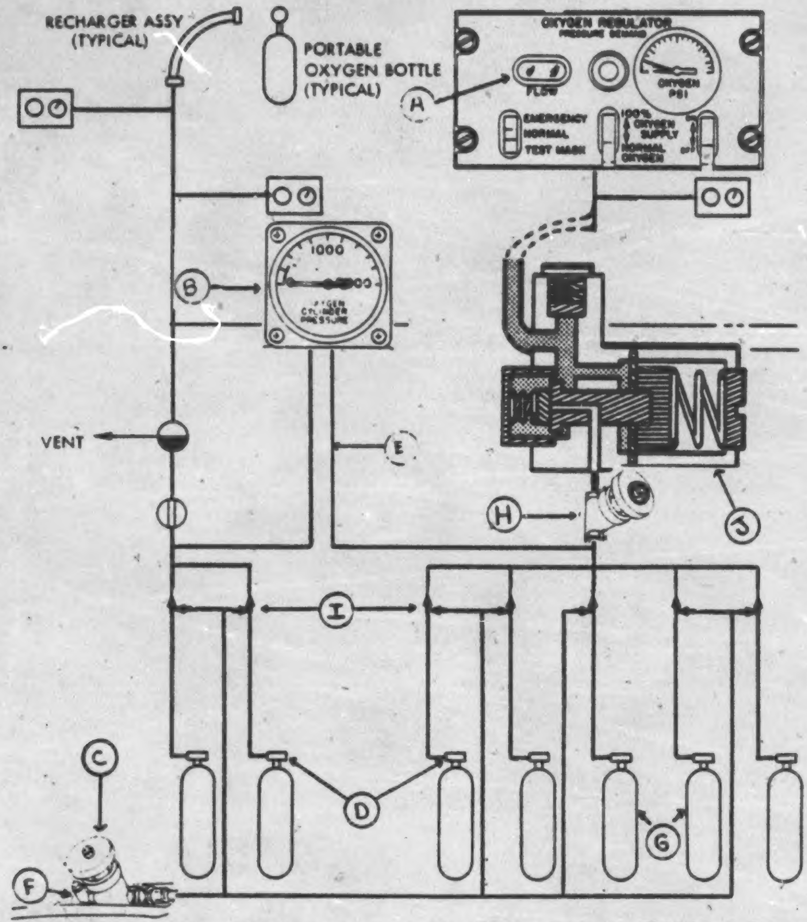
____5. The pressure gage is bourdon tube-operated.

2673

Answers to Frame 18: ✓ 1. ✓ 2. ✓ 3. ____ 4. ✓ 5.

Frame 19

Match the letter shown at each component with the correct name of that component from the list below.


RECHARGER ASSY (TYPICAL)
PORTABLE OXYGEN BOTTLE (TYPICAL)
OXYGEN REGULATOR
PRESSURE DEMAND
FLOW
OXYGEN PSI
EMERGENCY
NORMAL
TEST MASK
100% OXYGEN SUPPLY
NORMAL OXYGEN
A
B
1000
OXYGEN CYLINDER PRESSURE
VENT
E
H
J
I
C
D
G
F

____1. Oxygen Filler Valve

____2. System Shutoff Valve

____3. Oxygen Flow Indicator

____4. Pressure Reducing Valve

____5. Stainless Steel Tubing

____6. Oxygen Filler Connection

____7. Automatic Valve Assembly

____8. Cylinder Pressure Gage

____9. Check Valves

____10. High Pressure Cylinders

2674

Answers to Frame 19: __C__ 1. __H__ 2. __A__ 3. __J__ 4. __E__ 5.
__F__ 6. __D__ 7. __B__ 8. __I__ 9. __G__ 10.

2675

PROGRAMMED TEXT 3ABR42331-PT-401B

Technical Training

Aircraft Environmental Systems Mechanic

DEMAND OXYGEN EQUIPMENT

3 August 1978

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

2676

FOREWORD

This programmed text was prepared for use in the 3ABR42331 Instructional System. The material contained herein has been validated using thirty-one students enrolled in the 3ABR42331 course. Ninety percent of the students taking this text surpassed the criterion called for in the approved lesson objective. The average student required 50 minutes to complete the text.

OBJECTIVES

After completing this programmed text, you will be able to:

1. Relate four (4) of five (5) demand oxygen system components with their purpose.

INSTRUCTIONS

This programmed text presents material in small steps called "frames." After each frame you will find a number of statements and you are asked to select the statement/s that are true. Read the material in each frame before making a selection. The answers to each frame can be found at the top of the next page. If you select the correct answers, continue to the next frame. If you are wrong or in doubt, read the material again and correct yourself before continuing.

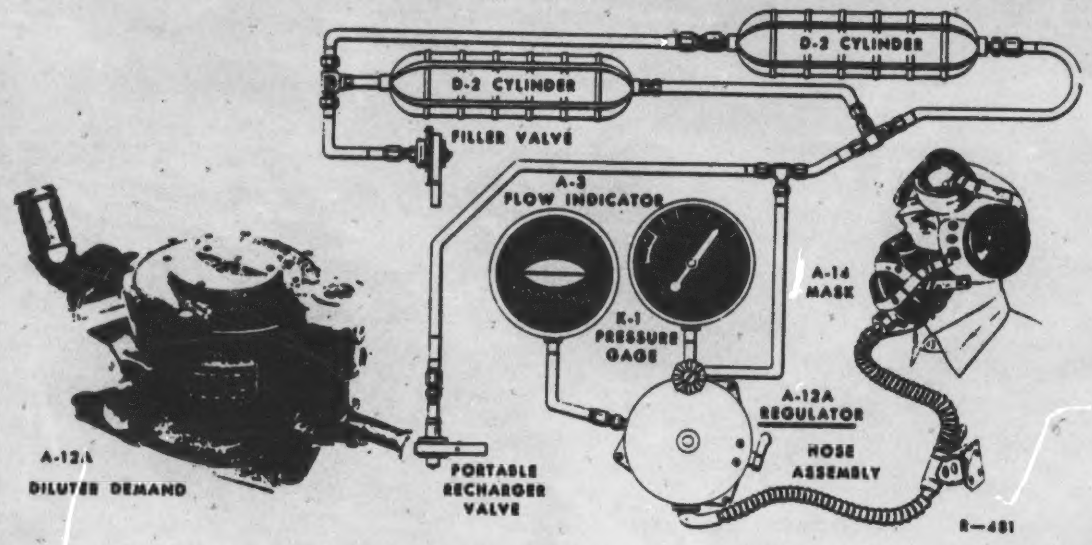
Supersedes 3ABR42331-PT-313, 2 June 1970.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCGTG/TTGU-P - 600; TTVSA - 1

2677

Frame 1

In the illustration below, D-2 low pressure gaseous oxygen cylinders are being used in the supply section of this system. Do we call this a gaseous oxygen system? No. Oxygen systems are usually referred to by the type of regulator installed in the distribution section of the system. The system shown has the A-12A diluter DEMAND regulator installed and we call this a DEMAND oxygen system. If the system below has a continuous flow regulator installed, it would be referred to as a continuous flow system, etc. Other components of the demand system are the A-14 demand mask, A-3 flow indicator, K-1 pressure gage, and the mask-to-regulator hose.

DEMAND OXYGEN SYSTEM


D-2 CYLINDER
D-2 CYLINDER
FILLER VALVE
A-3 FLOW INDICATOR
K-1 PRESSURE GAGE
A-14 MASK
A-12A REGULATOR
HOSE ASSEMBLY
A-12A DILUTER DEMAND
PORTABLE RECHARGER VALVE
R-481

Check the following statements that are true.

____ 1. Usually an oxygen system is referred to by the type of regulator installed.

____ 2. The A-12A regulator is the diluter demand type.

____ 3. The A-12A regulator is used only with liquid oxygen systems.

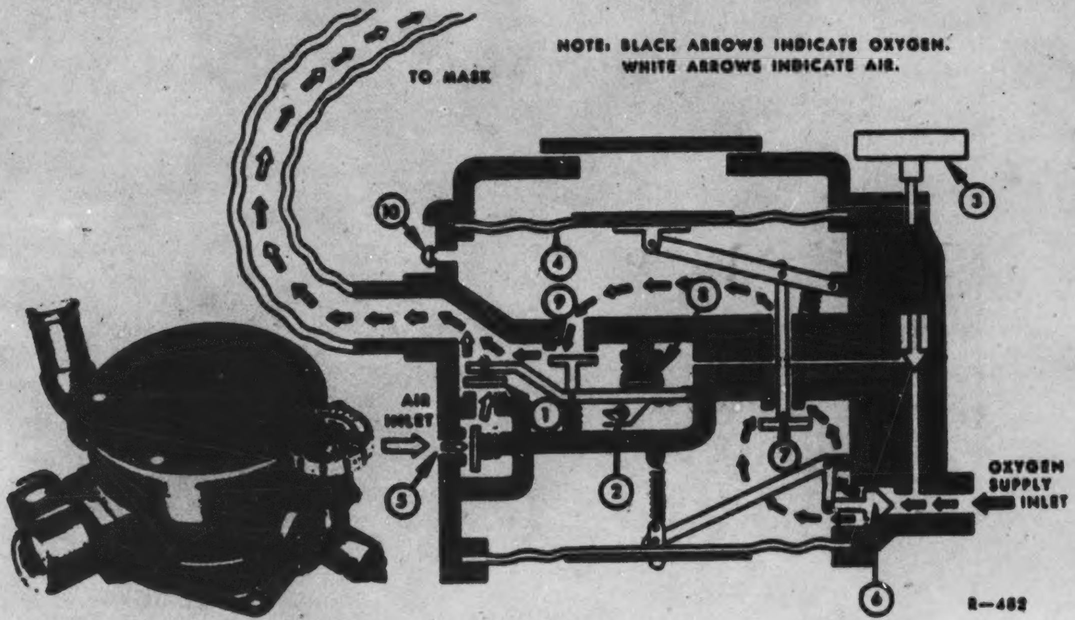
____ 4. The A-14 demand mask is used with the A-12A regulator.

2678

Answers to Frame 1: 1. ✓ 2. ✓ 3. ___ 4. ✓

Frame 2

The A-12A diluter demand regulator gets its name from the fact that it delivers oxygen to your lungs in response to the suction of your own breath, that is, on demand. To prolong the duration of the supply, the oxygen is automatically diluted (mixed) in the regulator with suitable amounts of air up to a certain altitude. The A-12A is one of the oldest oxygen regulators in use and we will discuss it first because the newer regulators are patterned after the A-12A; this will become apparent as we continue. For a better understanding of the A-12A, mentally match the list of components with the numbers in the arrowed circles.


NOTE: BLACK ARROWS INDICATE OXYGEN.
WHITE ARROWS INDICATE AIR.
TO MASK
AIR INLET
OXYGEN SUPPLY INLET
1
2
3
4
5
6
7
8
9
10
R-482

1. Air Metering Port.
2. Diluter Control Cam.
3. Emergency Valve.
4. Demand Diaphragm.
5. Check Valve.
6. Pressure Reducing Valve.
7. Demand Valve.
8. Aneroid.
9. Oxygen Metering Port.
10. 2nd Stage Relief Valve.

Type A-12A Diluter Demand Oxygen Regulator (Aro).

Check the following statements that are true.

____ 1. The A-12A delivers oxygen on demand.

____ 2. The A-12A delivers 100% oxygen at all times.

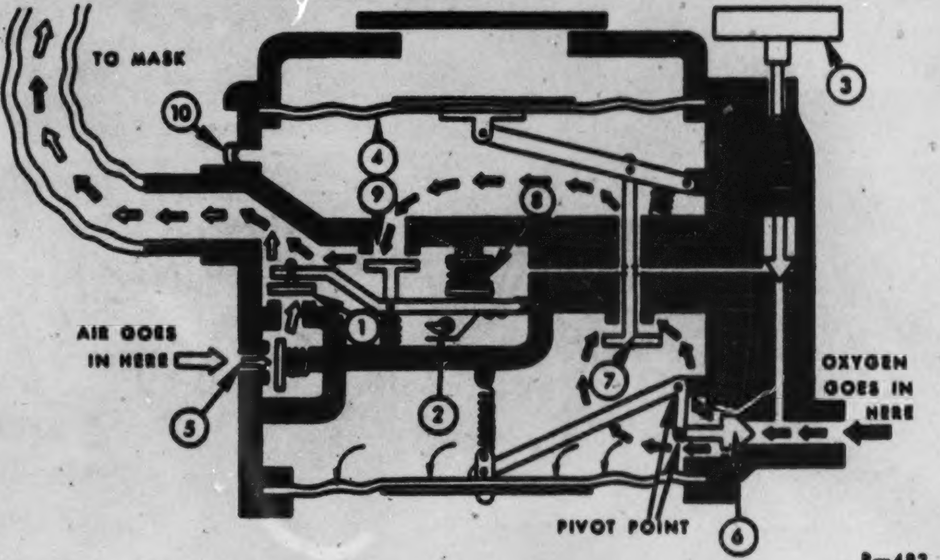
____ 3. Air is mixed with the oxygen in the regulator up to a certain altitude.

2679

Answers to Frame 2: 1. ✓ 2. ___ 3. ✓

Frame 3

As we have stated, the A-12A is a diluter demand regulator. This simply means that air and oxygen are mixed (diluted) and supplied to the user when he/she inhales (demands) oxygen. When the user inhales, he/she closes a valve in the mask and opens a valve in the regulator. When he/she exhales, this process is reversed. Starting where the oxygen enters the regulator from the supply section you find the pressure reducing mechanism. The pressure reducing valve (6) is attached through levers to a rubber diaphragm. (See schematic.) As the pressure of the oxygen increases in this first stage chamber, it forces the diaphragm down and the attached lever closes the pressure reducing valve (6). 40 to 60 psi on the diaphragm closes the valve and it remains closed until the pressure drops from the oxygen being used. Note the spring attached to the center of the diaphragm will also help pull it up which will open the valve.



R—483

1. Air Metering Port.
2. Diluter Control Cam.
3. Emergency Valve.
4. Demand Diaphragm.
5. Check Valve.
6. Pressure Reducing Valve.
7. Demand Valve.
8. Aneroid.
9. Oxygen Metering Port.
10. 2nd Stage Relief Valve.

Type A-12A Diluter Demand Oxygen Regulator (Aro).

Check the following statements that are true.

____ 1. 40 to 60 psi closes the pressure reducing valve.

____ 2. The user does not have to inhale to get oxygen from the A-12A.

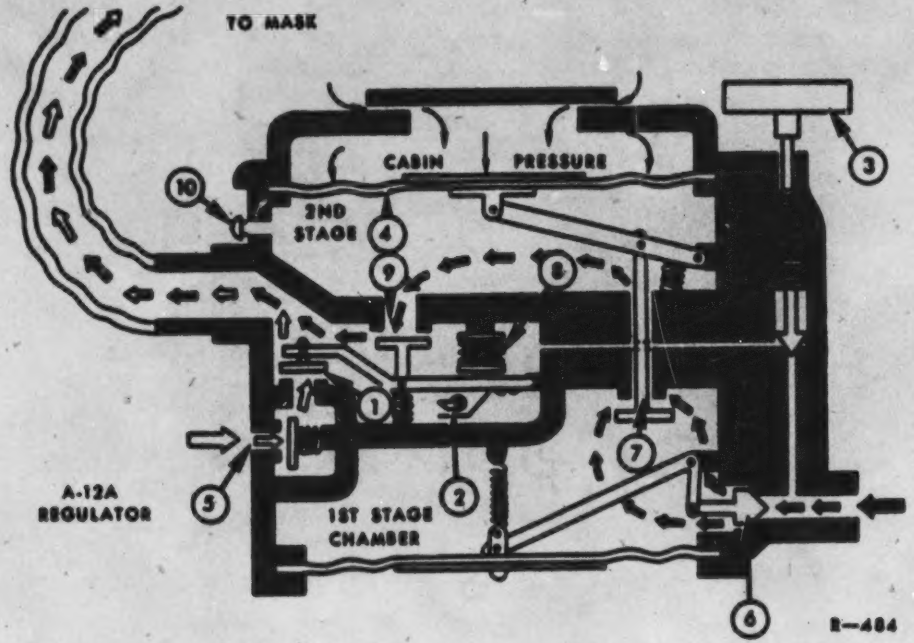
____ 3. First stage reducing is 40 to 60 psi.

2680

Answers to Frame 3: 1. ✓ 2. ___ 3. ✓

Frame 4

We now have 40 to 60 psi in the first stage chamber. The only way for the oxygen to get out of here is up around the demand valve (7). (See schematic.) The demand valve (7) is controlled through levers attached to the demand diaphragm (4). The demand diaphragm is controlled in turn by the breathing of the user. Cabin pressure acts on the upper side of the demand diaphragm (4). As the user inhales oxygen is drawn from the bottom side of the diaphragm. This allows cabin pressure to force the diaphragm down. The connecting levers then open the demand valve (7) and more oxygen is allowed in the upper or 2nd stage chamber. Once the 2nd stage chamber pressure equals the cabin pressure, oxygen pressure raises the diaphragm enough to close the demand valve. The above sequence is the way 1st stage pressure is reduced for pilot use.



1. Air Metering Port.
2. Diluter Control Cam.
3. Emergency Valve.
4. Demand Diaphragm.
5. Check Valve.
6. Pressure Reducing Valve.
7. Demand Valve.
8. Aneroid.
9. Oxygen Metering Port.
10. 2nd Stage Relief Valve.

Check the following statements that are true.

___ 1. The demand valve is controlled by the demand diaphragm.

___ 2. The demand diaphragm is controlled by the user.

___ 3. Oxygen enters the second stage chamber through the demand valve.

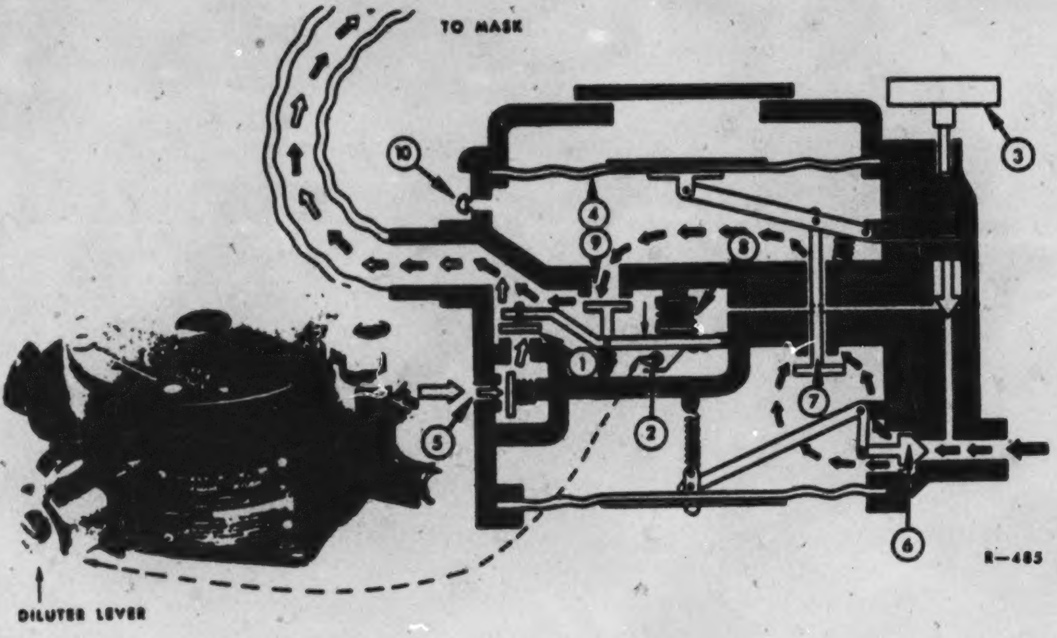
___ 4. The demand diaphragm directly controls the pressure reducing valve.

2681

Answers to Frame 4: 1. ✓ 2. ✓ 3. ✓ 4. ___

Frame 5

When the user inhales (demands oxygen) the oxygen leaves the 2nd stage chamber thorugh the oxygen metering port (9), and travels to the user in the mask-to-regulator hose. At the same time, cabin air is allowed to mix with (dilute) the oxygen. The air enters through the check valve (5); then a specified amount is metered through the air metering port (1). Note that the oxygen metering port and air metering port are attached to a common lever which moves up or down. The diluter control cam (2) has two positions which are selected by the diluter lever, (see illustration). With the diluter lever positioned to "normal oxygen," the aneroid (8) will control the movement of the common lever. And as cabin altitude increases, the aneroid will expand an gradually close off the air metering port. At 32,000 feet the air metering port will be completely closed and the user will get 100% oxygen automatically



1. Air Metering Port.
2. Diluter Control Cam.
3. Emergency Valve.
4. Demand Diaphragm.
5. Check Valve.
6. Pressure Reducing Valve.
7. Demand Valve.
8. Aneroid.
9. Oxygen Metering Port.
10. 2nd Stage Relief Valve.

Check the following statements that are true.

___ 1. Up to 32,000 feet, air and oxygen are mixed.

___ 2. The check valve (5) shuts off the air at 32,000 feet.

___ 3. With the diluter lever in normal oxygen, the aneroid controls the air.

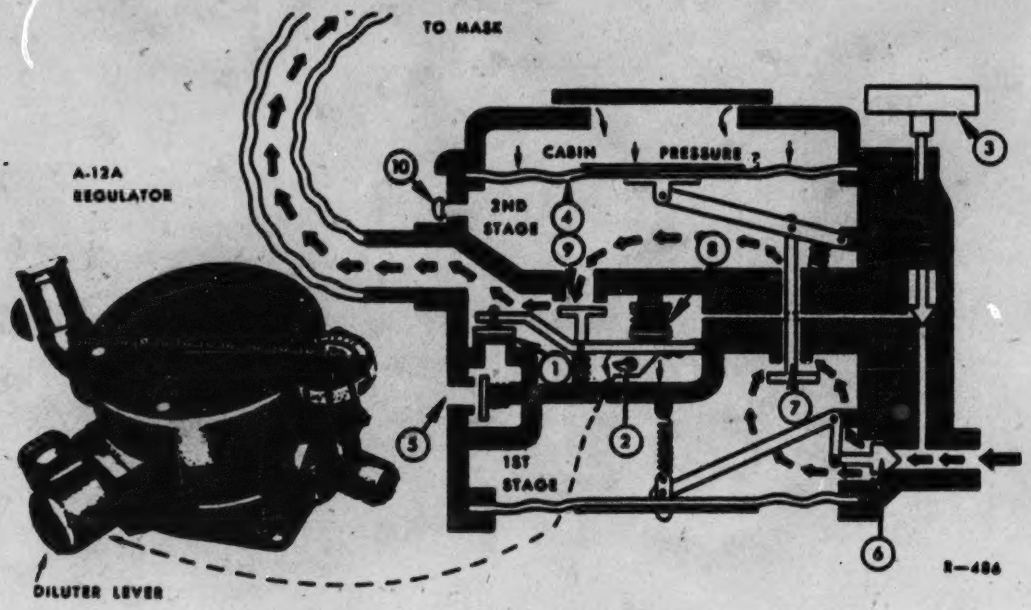
___ 4. Above 32,000 feet, the user automatically gets 100% in the normal oxygen position.

2682

Answers to Frame 5: 1. ✓ 2. ___ 3.

Frame 6

As we have stated, with the diluter lever in "NORMAL OXYGEN," the aneroid (8) will control the amount of air entering the regulator and at 32,000 feet it closes air metering port. When the diluter lever is manually placed in the "100% OXYGEN" position, the diluter control cam (2) swings down as indicated in the schematic and engages a strip of metal attached to the common lever and forces the lever down. This action overrides the aneroid and closes off the air metering port (1). This action supplies the user with 100% oxygen anytime he/she so desires.



1. Air Metering Port.
2. Diluter Control Cam.
3. Emergency Valve.
4. Demand Diaphragm.
5. Check Valve.
6. Pressure Reducing Valve.
7. Demand Valve.
8. Aneroid.
9. Oxygen Metering Port.
10. 2nd Stage Relief Valve.

Check the following statements that are true.

___ 1. The diluter lever allows the user to select 100% oxygen at anytime.

___ 2. The diluter lever moves the diluter control cam.

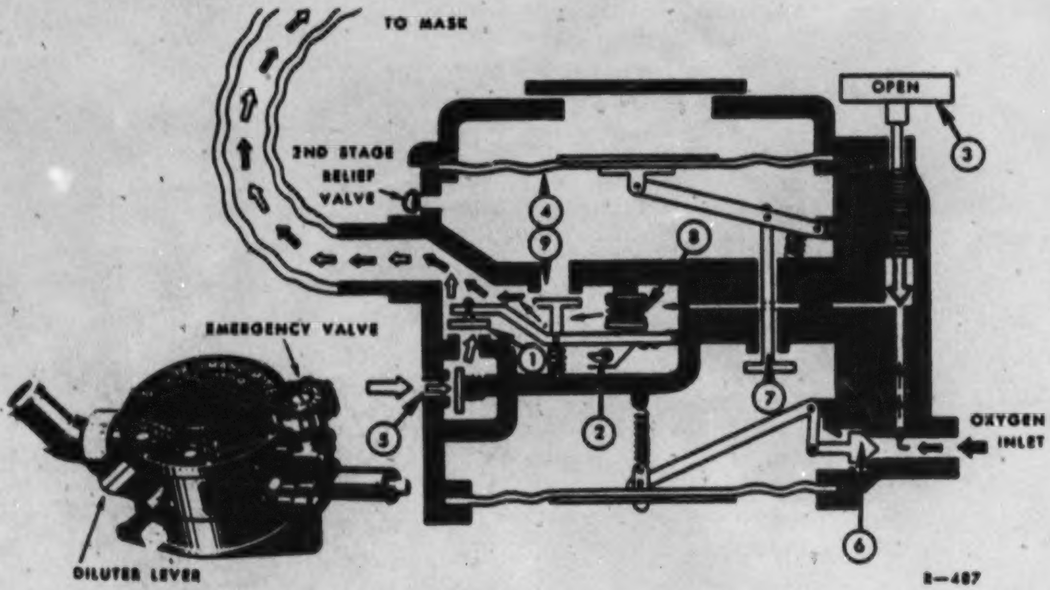
___ 3. The diluter lever overrides the aneroid when placed in 100% oxygen.

___ 4. The diluter lever controls the first stage reducing.

Answers to Frame 6: 1. ✓ 2. ✓ 3. ✓ 4.

Frame 7

The only section of the A-12A we have not covered is the EMERGENCY VALVE (3). This is a hand-wheel operated valve that opens an orifice as shown in the schematic. When the emergency valve (3) is turned out, oxygen will flow through this machined orifice in a continuous flow to the user. Should pressure build up in the regulator, a 2nd stage relief valve will open at 30 to 41 inches of water pressure to relieve it. The emergency valve is provided in case the regulator malfunctions or the user is unable to breathe normally. Remember, the normal function of this regulator requires that the user demand (inhale).



1. Air Metering Port.
2. Diluter Control Cam.
3. Emergency Valve.
4. Demand Diaphragm.
5. Check Valve.
6. Pressure Reducing Valve.
7. Demand Valve.
8. Aneroid.
9. Oxygen Metering Port.

Check the following statements that are true.

____ 1. The emergency valve allows the user to get a continuous flow of oxygen.

____ 2. The 2nd stage relief valve opens at 30 to 41 inches of water pressure.

____ 3. The emergency valve will open automatically.

____ 4. The normal function of the A-12A requires the user to inhale.

2684

Answers to Frame 7: 1. ✓ 2. ✓ 3. __ 4. ✓

Frame 8

SELF TEST QUIZ

In each question, circle the letter that identifies the correct answer. Check your answers on the top of the next page.

1. The second stage relief valve in the A-12A will open and relieve pressure at

   a. cabin pressure.
   b. 5 psi.
   c. 15 inches of mercury.
   d. 30 to 41 inches of water.

2. The A-12A oxygen regulator is a

   a. diluter demand regulator.
   b. pressure demand regulator.
   c. continuous flow regulator.
   d. diluter pressure demand regulator.

3. A complete oxygen system with the A-12A regulator installed would be referred to as a

   a. high pressure oxygen system.
   b. diluter oxygen system.
   c. demand oxygen system.
   d. low pressure oxygen system.

4. The pressure reducing mechanism in the A-12A oxygen regulator reduces cylinder pressure to

   a. 40 to 60 inches of water.
   b. 40 to 60 inches of mercury.
   c. 40 to 60 psi.
   d. cabin pressure.

5. If the user of the A-12A regulator became injured or for some other reaso could not breathe normally, he would

   a. put the diluter lever in "normal oxygen."
   b. use a walk-around bottle.
   c. open the emergency valve.
   d. place the diluter lever in "100% oxygen."

6. In the A-12A demand regulator, the demand diaphragm opens and closes the demand valve in direct response to

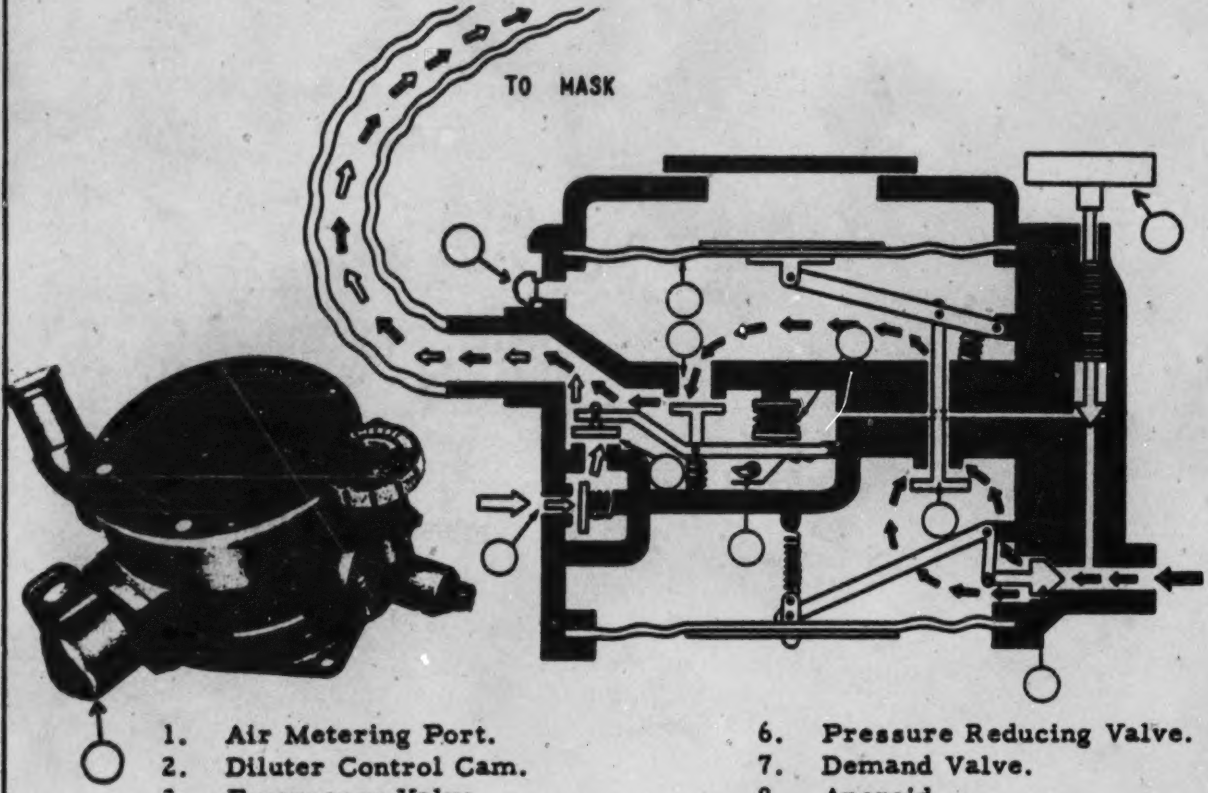
   a. atmospheric pressure.
   b. the setting of the diluter lever.
   c. the aircraft altitude.
   d. the breathing of the user.

2685

Answers to Frame 8: 1. d 2. a 3. c 4. c 5. c 6. d

Frame 9

Instructions: Place the number of the part in the list below in the correct arrowed circle.

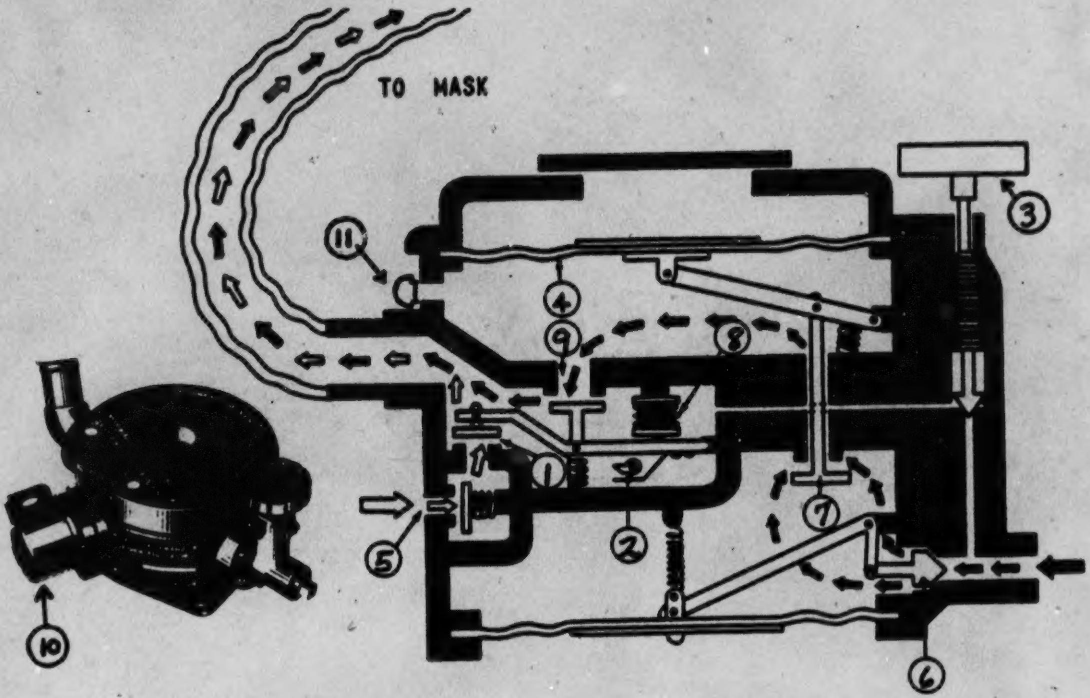


1. Air Metering Port.
2. Diluter Control Cam.
3. Emergency Valve.
4. Demand Diaphragm.
5. Check Valve.
6. Pressure Reducing Valve.
7. Demand Valve.
8. Aneroid.
9. Oxygen Metering Port.
10. Diluter Lever.
11. Relief Valve.

Type A-12A Diluter Demand Oxygen Regulator (Aro).

2686

Answers to Frame 9:



1. Air Metering Port.
2. Diluter Control Cam.
3. Emergency Valve.
4. Demand Diaphragm.
5. Check Valve.
6. Pressure Reducing Valve.
7. Demand Valve.
8. Aneroid.
9. Oxygen Metering Port.
10. Diluter Lever.
11. Relief Valve.

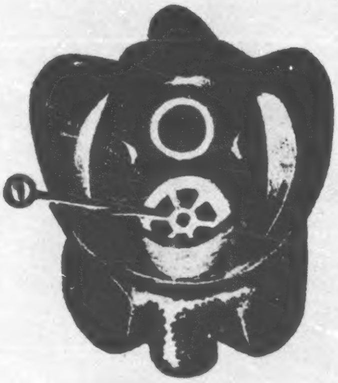
Type A-12A Diluter Demand Oxygen Regulator (Aro).

No response required.

2687

Frame 10

The A-14 or A-14A demand mask is used with the A-12A demand oxygen regulator. The demand mask has a single outlet valve (1). This is a one-way check valve consisting of a circular flap of rubber which opens the outlet when the user exhales and closes it when he inhales. Proper regulator operation depends upon how well the mask fits and how well it is functioning. Oxygen masks are normally maintained by Personal Equipment Specialists and by the user. Knowing how they function will help you understand more clearly the oxygen regulators.



A-14A Demand Mask.

Check the following statements that are true.

___ 1. The A-14 mask has a single outlet valve.

___ 2. Regulator operation is affected by the mask.

___ 3. The demand mask is used with a demand regulator.

___ 4. Any mask can be used with any regulator.

Answers to Frame 10: 1. ✓ 2. ✓ 3. ✓ 4

Frame 11

Another part of the demand oxygen system is the flow indicator and pressure gage. These two indicators are located close to the oxygen regulator and should be clearly visible to the user. The A-3 flow indicator is diaphragm operated and "blinks" at the user as he/she breathes. This lets the user know that oxygen is flowing through the regulator. The K-1 pressure gage is bourdon tube operated. As pressure inside the tube tends to straighten it, the pointer is moved through a system of levers. The pressure gage lets the user know how much oxygen is in the system that he/she is breathing from.

BLINKER
OXYGEN FLOW
INDICATOR

A-3 Flow Indicator.

100
200
300
400
500
OXYGEN
CYL.
PRESSURE

K-1 Pressure Gage.

Check the following statements that are true.

___ 1. The K-1 pressure gage is bourdon tube operated.

___ 2. The A-3 flow indicator operates from a bourdon tube.

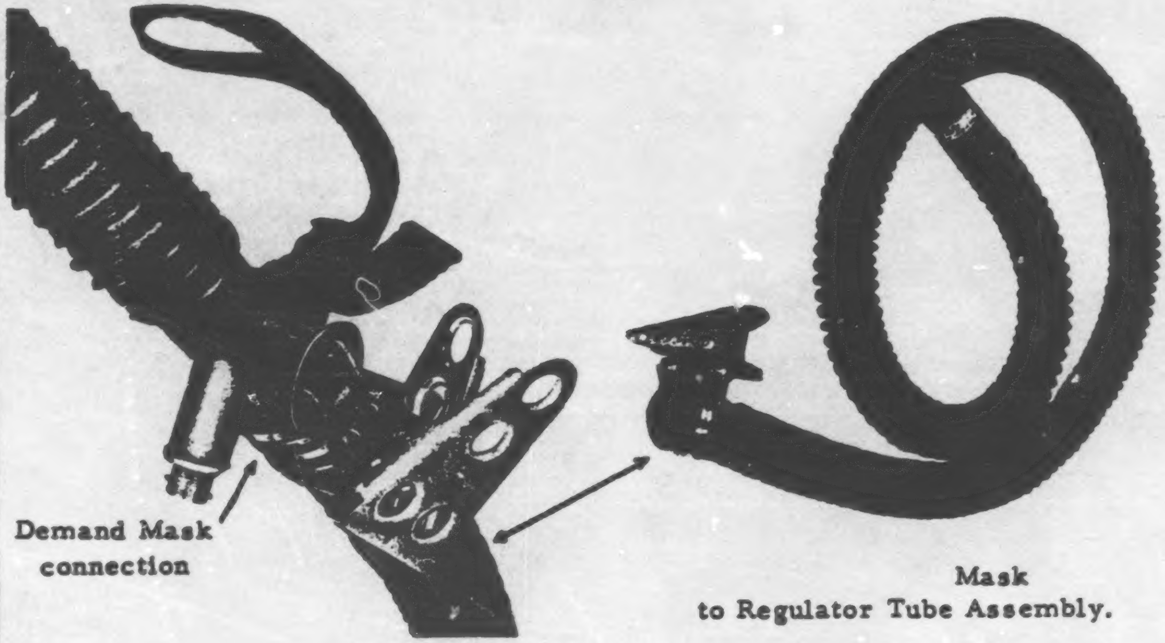
___ 3. The flow indicator "blinks" as the user breathes.

___ 4. The flow indicator and pressure gage are located near the regulator.

Answers to Frame 11. 1. ✓ 2. ___ 3. ✓ 4. ✓

Frame 12

Shown below is the flexible tubing or hose used to deliver the oxygen from the regulator to the mask. The plain end of the mask to regulator tube assembly (right below) is clamped to the outlet elbow of the demand regulator. The other end of the hose contains a clothing clip, dust cap, and female part of a quick disconnect. The male part of the quick disconnect is attached to hose connected to the demand mask (left below). A leakproof connection is made when both halves of the quick disconnect are joined.



Check the following statements that are true.

___ 1. One end of the mask to regulator tube has a clothing clip and a dust cap.

___ 2. The male part of the quick disconnect is attached to the mask hose.

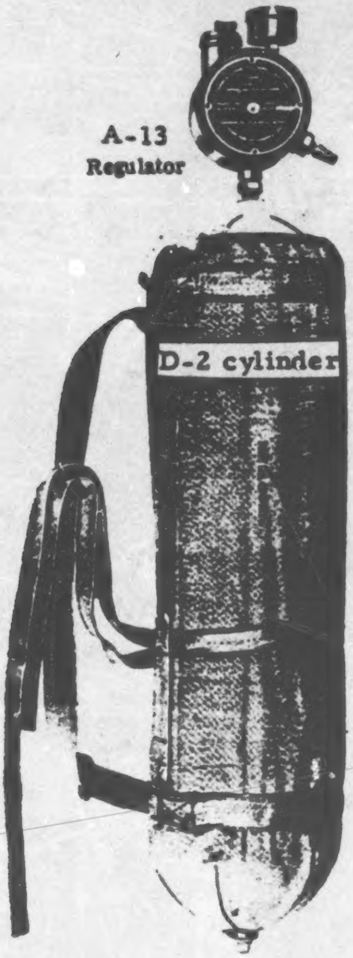
___ 3. The quick disconnect will always leak.

2690

Answers to Frame 12: 1. ✓ 2. ✓ 3.

Frame 13

Other than the station regulators like the A-12A, regulators are also used on small portable cylinders called "walk-around bottles." These bottles are carried on the larger type aircraft where crew members have to leave their station regulators to perform various duties while the aircraft is in flight. The older combination A-13 demand regulator and D-2 cylinder will supply oxygen for about 30 minutes before it has to be recharged from the aircraft main system. The A-13 demand regulator has no air inlet and supplies 100% oxygen on demand. The D-2 cylinder is serviced with 400 to 450 psi of oxygen. The carrying bag is used with this combination because of the weight of the D-2 cylinder.



Check the following statements that are true.

___ 1. Walk-around bottles would be needed on fighter aircraft.

___ 2. The A-13 is a straight demand regulator.

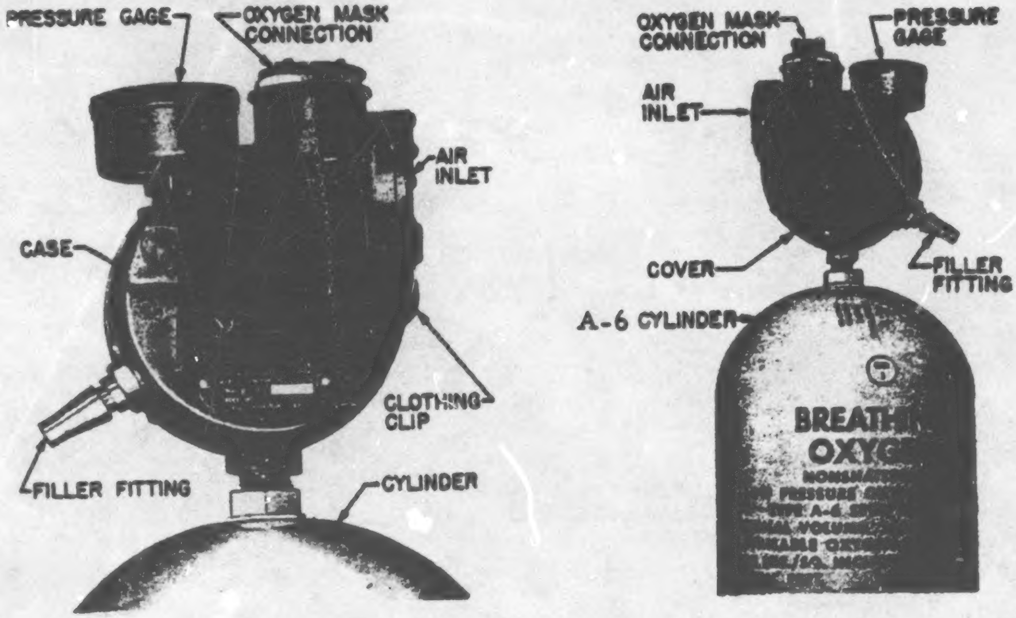
___ 3. The D-2 cylinder is filled from the aircraft system.

___ 4. The A-13 regulator supplies 100% oxygen on demand.

Answers to Frame 13: 1. ___ 2. ✓ 3. ✓ 4. ✓

Frame 14

The regulators used on walk-around bottles function the same as station regulators (A-12A) but are constructed somewhat different. The newer A-15 diluter demand regulator and A-6 cylinder are also part of the demand oxygen equipment. All portable regulators are constructed similar to the A-15 below with a 0 to 500 psi pressure gage, direct oxygen mask connection, filler fitting and clothing clip. The A-15 has an air inlet which tells us it's a diluter demand type. The A-6 cylinder is not as heavy as the D-2 cylinder previously discussed and a clothing clip is provided to attach it to the flying suit of the user. The A-6 is also serviced to 400-450 psi. The user has to constantly watch the pressure gage on walk-around bottles and recharge the cylinder before it is empty.


PRESSURE GAGE
OXYGEN MASK CONNECTION
AIR INLET
CASE
CLOTHING CLIP
FILLER FITTING
CYLINDER
OXYGEN MASK CONNECTION
PRESSURE GAGE
AIR INLET
COVER
FILLER FITTING
A-6 CYLINDER
BREATHI
OXYG

A-15 Oxygen Regulator.

Check the following statements that are true.

___ 1. The A-15 is a portable, diluter demand regulator.

___ 2. On walk-around bottles, the cylinder is serviced through the regulators.

___ 3. Portable regulators are constructed the same as station regulators.

___ 4. The above unit is attached to the clothing of the user.

2692

Answers to Frame 14   1. ✓   2. ✓   3. ___   4. ✓

Frame 15

This concludes our discussion on demand oxygen equipment. The equipment covered in this text will be available in the classroom or oxygen lab for you to handle and inspect. Remember, oxygen equipment is depended upon by the user as his main life support at high altitudes. Failure of this equipment for a 15 second period may be fatal to the user. Also, while you are working with and handling oxygen and equipment, don't forget the safety precautions that apply to oxygen.

SELF TEST QUIZ

Circle the correct answer and check your answer on the next page.

1. The A-15 portable regulator differs from the A-13 portable regulator in that the

   a. A-15 has a demand function only.
   b. A-15 is diluter demand.
   c. A-13 has a filler fitting.
   d. A-13 has a pressure gage.

2 The type of oxygen mask used with the A-12A regulator in a demand oxygen system is the

   a. A13 pressure mask.
   b. A14 demand mask.
   c. K-1 diluter mask.
   d. A-3 mask.

3. The A-6 portable cylinder is used in combination with the

   a. A-15 diluter demand regulator.
   b. A-12A pressure regulator.
   c. A-13A diluter regulator.
   d. A-14 fixed regulator.

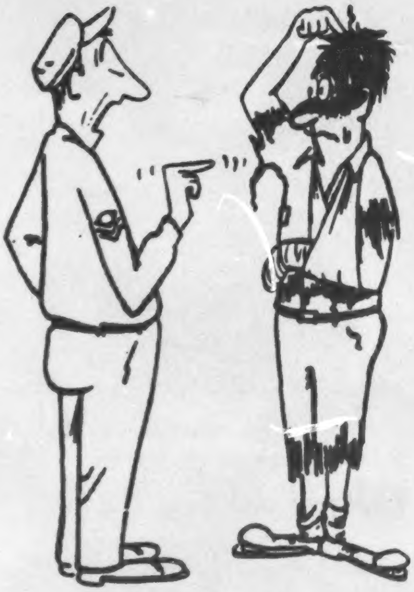
4. The A-13 and A-15 oxygen regulators are

   a. both diluter demand.
   b. station regulators like the A-12A.
   c. used on walk-around bottles.
   d. constructed the same as the A-12A.

2693

Answers to Frame 15: 1. b 2. b 3. a 4. c

Remember Your Oxygen Safety



Keep all petroleum products (oil, grease, fuel, etc) away from oxygen equipment.

Make sure that body, clothing, and protective equipment are clean and free of petroleum products (hair oil is a petroleum product) before performing maintenance on oxygen system.

END OF TEXT

2694

PROGRAMMED TEXT
3ABR42331-PT-401C

Technical Training

Aircraft Environmental Systems Mechanic

PRESSURE DEMAND OXYGEN EQUIPMENT

15 March 1978

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE

DO NOT USE ON THE JOB

2695

FOREWORD

This programmed text was prepared for use in the 3ABR42331 instructional system. The materials contained herein have been validated using 30 students enrolled in the 3ABR42331 course. Eighty percent of the students taking this text surpassed the criterion called for in the approved lesson objective. The average time required was 2.8 hours to complete the text.

OBJECTIVE

Relate five (5) of six (6) gaseous oxygen system components to their operation.

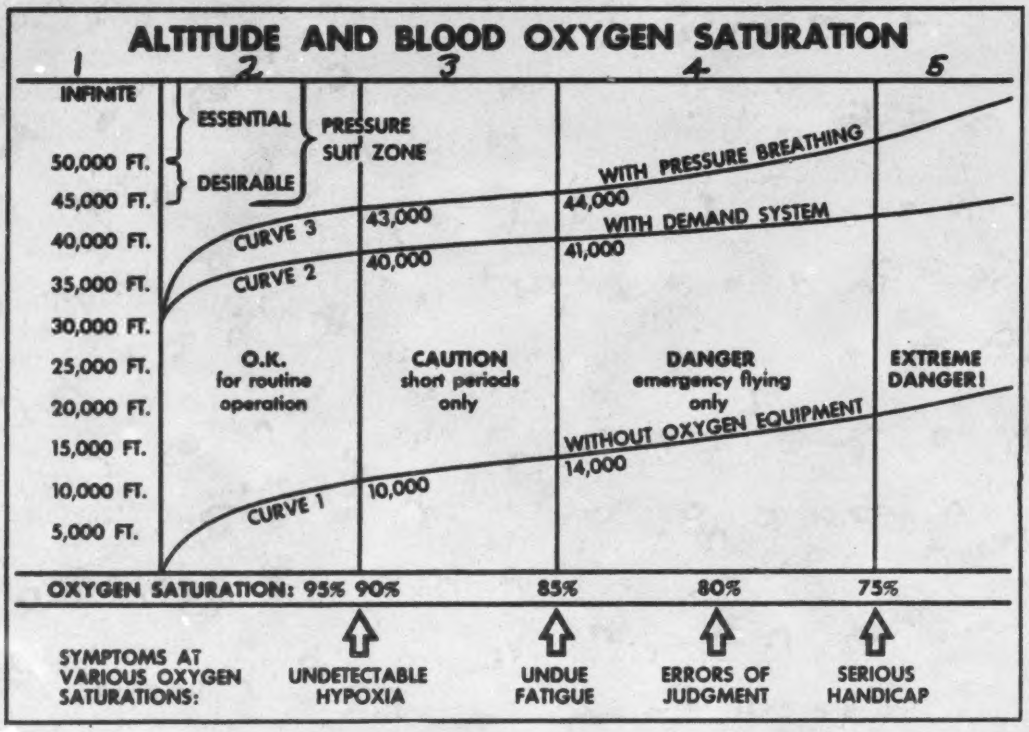
INSTRUCTIONS

This programmed text will review some of the parts taught in previous lessons on gaseous oxygen systems and cover in depth the operation of the regulators and mask that make the system a pressure demand system. In addition, the reason the pressure demand system is needed is explained.

The information in this text is presented in small steps called frames. After each frame you are asked to respond in some manner. Read the material carefully, then make your response as directed. The answers for the responses can be found on top of the next page. If you answered correctly, continue on to the next frame. If you are wrong or in doubt, read the technical material again and correct yourself before continuing.

Supersedes 3ABR42231-PT-313A, 22 March 1971.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 300; TTVSA - 1

The diluter demand regulator sends oxygen or oxygen mixed with air to the user on demand or when he breathes. This is all just fine until we reach a height of about 40,000 feet. From 40,000 feet up, the human body needs oxygen under pressure to work the way it should. At sea level pressure, carbon dioxide and water are stable in the blood stream and oxygen saturation of the blood is 100%. At low atmospheric pressure (high altitude), carbon dioxide and water vaporize in the lungs and pressure builds up that keeps oxygen from entering the lungs. By adding pressure to the oxygen (pressure breathing), we get rid of this pressure in the lungs and force the carbon dioxide out and force oxygen in. Look at the chart below for a better idea of the equipment required.



Using the chart above to determine the approximate altitude for each of the questions written below. Place your answer in the blank provided.

_____1. What is the limit of a demand oxygen regulator?

_____2. What is the safe limit a person can reach without oxygen equipment?

_____3. At what altitude is a pressure suit desirable?

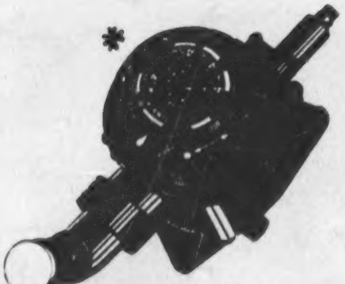
_____4. How high can a pilot safely fly with a pressure breathing system?

8697

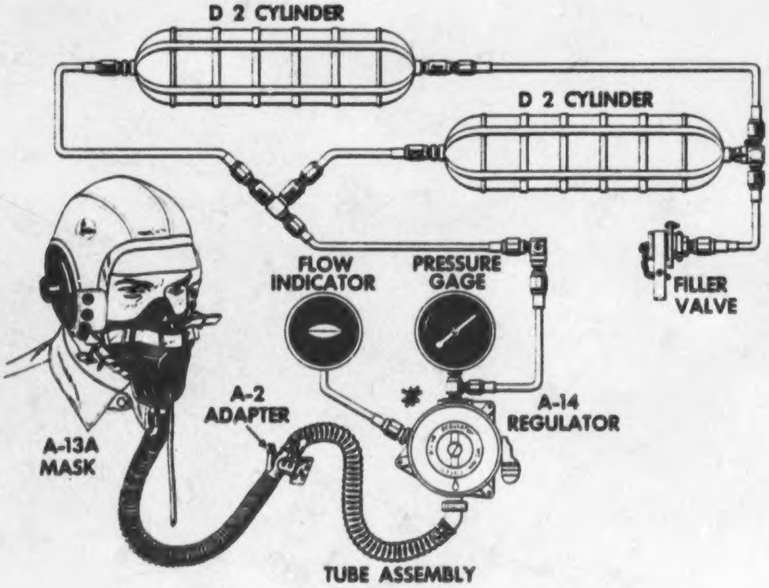
Answers to Frame 1: 1. 40,000 2. 10,000 3. 45,000 4. 44,000

Frame 2

With pressure breathing, as shown in the chart in the past frame, we are safe up to a height of about 50,000 feet. Above this height, the carbon dioxide and water vapor pressure will rise to a point where any more of an increase in oxygen pressure would damage the lungs. Also, above 50,000 feet, a pressure suit is needed in case cabin pressure is lost. Without any pressure, blood will boil at 60,000 feet, so you can see the need of this equipment. Now that you know why we need pressure breathing, let us talk about some of the regulators that make up a pressure-demand system. Shown below is a complete oxygen system with the A-14 pressure demand regulator used. Note that the change found between this system and the straight demand system is in the regulator and mask used. The A-14 is a pressure demand regulator and the A-13A is a pressure demand mask.



A-14



Check the following statements that are true.

_____1. The A-14 is a pressure demand oxygen regulator.

_____2. The A-12A regulator can be used above 50,000 feet.

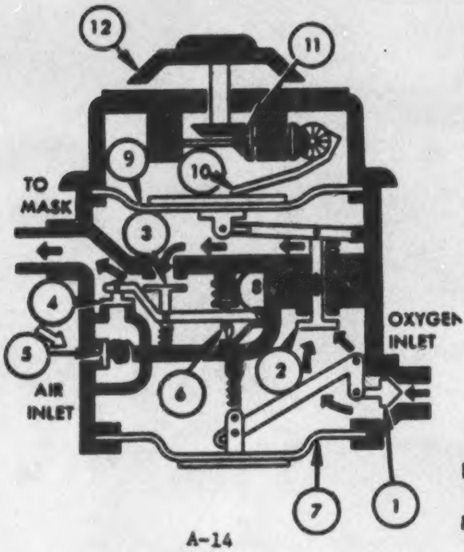
_____3. Above 50,000 feet, a pressure suit is essential.

2698

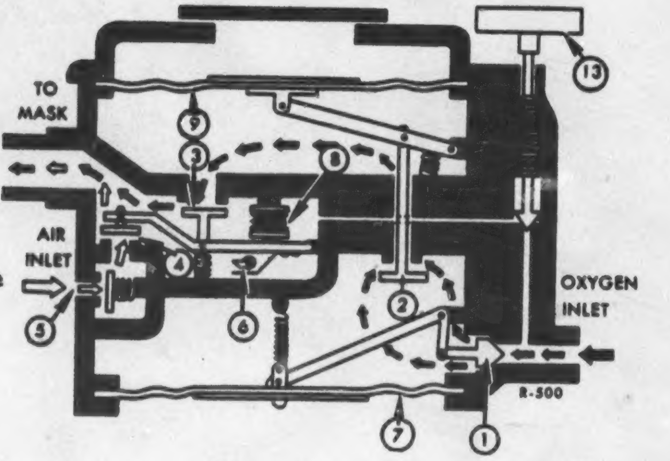
Answers to Frame 2: ✓ 1. ____ 2. ✓ 3.

Frame 3

Take a look at the difference between the A-14 (top) and the A-12A (lower) regulators. If you place your finger over the top section of the A-14 you will see that we have an A-12A regulator again, except for the EMERGENCY VALVE (13) on the A-12A. One of the settings on the A-14 dial will serve as an emergency setting. Keep in mind when we talk about the A-14 regulator that except for the pressure breathing section located on top, this regulator will work the same way as the A-12A. Match all the parts listed below with the A-14 regulator.


12
11
9
10
TO MASK
3
4
8
5
AIR INLET
6
2
OXYGEN INLET
7
1

A-14


13
TO MASK
9
3
8
AIR INLET
4
5
6
2
OXYGEN INLET
R-500
7
1

A-12A

1. Pressure Reducing Valve
2. Demand Valve
3. Oxygen Metering Valve
4. Air Valve
5. Check Valve
6. Diluter Valve
7. Diaphragm
8. Aneroid
9. Demand Diaphragm

*10. Pressure Breathing Lever
*11. Pressure Breathing Gear Train
*12. Pressure Breathing Control Knob
**13. Emergency Valve

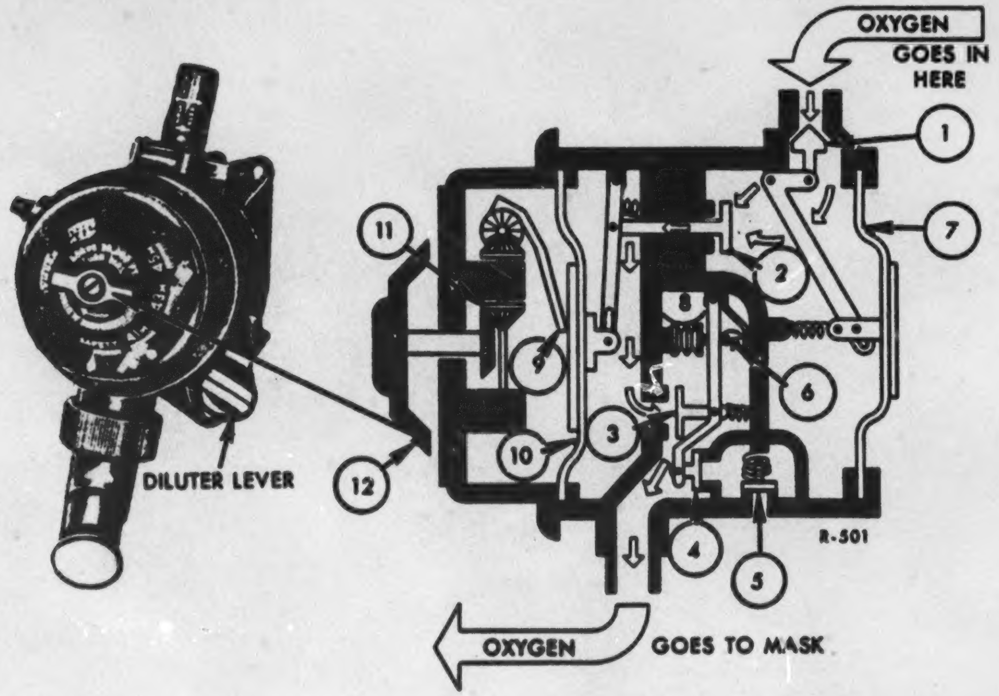
*A-14 **A-12A

No Response Required

2699

Frame 4

The A-14 regulator is a pressure-breathing, diluter-demand regulator. The diluter lever works the diluter control cam (6). In the 100% oxygen position, the diluter control cam will press down on the metal strip hooked to the common lever and close the air valve (4). The regulator is now delivering 100% oxygen. With the diluter lever in the NORMAL OXYGEN position, the air is controlled by the aneroid (8) up to 32,000 feet at which time it, the air valve (4), will be closed off (same as the A-12A). Match the part name with the number in the arrowed circles for a better understanding.



A-14 PRESSURE-BREATHING DILUTER-DEMAND REGULATOR

1. Pressure Reducing VAlve
2. Demand Valve
3. Oxygen Metering Valve
4. Air Valve
5. Check Valve
6. Diluter Control Cam
7. Diaphragm
8. Aneroid
9. Pressure Breathing Lever
10. Demand Diaphragm
11. Pressure Breathing Gear Train
12. Pressure Breathing Control Knob

Place the number of the part in the blank space next to the statement that best describes its operation/use.

_____a. Worked by the diluter lever.

_____b. The diluter control cam presses on a metal strip attached to the common lever and closes this valve.

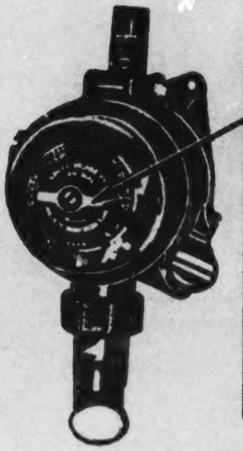
_____c. Controls the air up to 32,000 feet with the diluter lever

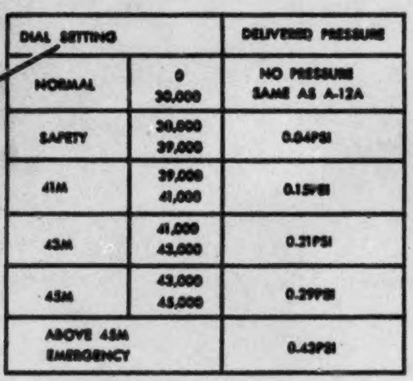
Answers to Frame 4: 6 a. 4 b. 8 c.

2700

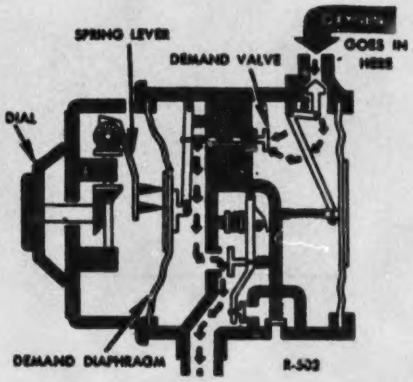
Frame 5

The pressure breathing control knob or selector dial on the A-14 has six (6) positions that the user can choose from as he goes from sea level to above 45,000 feet. As shown in the regulator sketch below, the dial is hooked to a gear train which in turn will crank down the spring lever and force the demand diaphragm to open the demand valve. The first column in the chart shown lists the six different settings. In NORMAL, no pressure is placed on the demand diaphragm and the A-14 will work the same as the A-12A. The second column lists the altitude at which each setting should be used, and the third column lists the pressure that is sent to the mask. (Note: On the dial setting, "M" = thousands). In case of emergency, the setting "ABOVE 45M" is used.





DIAL SETTING		DELIVERED PRESSURE
NORMAL	0 30,000	NO PRESSURE SAME AS A-12A
SAFETY	30,000 39,000	0.04PSI
41M	39,000 41,000	0.15PSI
43M	41,000 43,000	0.21PSI
45M	43,000 45,000	0.29PSI
ABOVE 45M EMERGENCY		0.43PSI



PRESSURE SETTINGS AND PRESSURE DELIVERED.

Refer to the chart above to complete each of the following statements.

1. The emergency setting on the A-14 regulator delivers __________ PSI to the mask.

2. The safety setting will be used at altitudes between __________ and __________.

3. At the 43M setting __________ PSI is delivered to the mask.

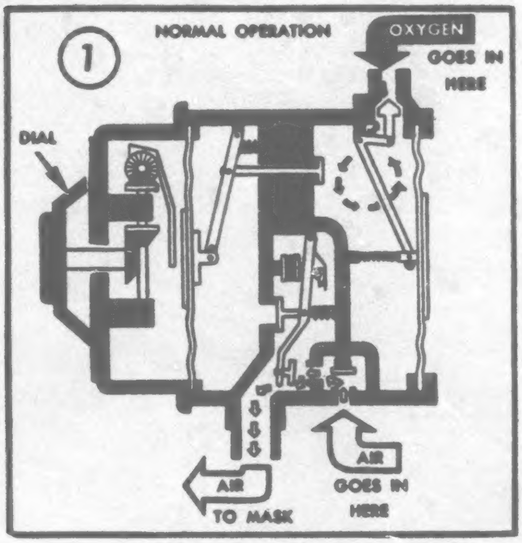
4. At 39,000 feet the dial setting should be changed from SAFETY to __________.

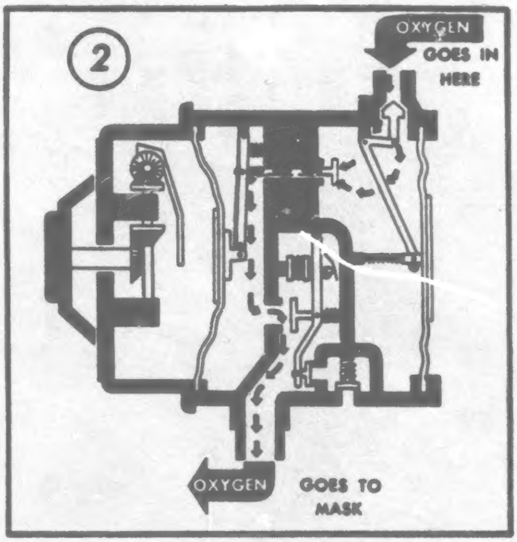
2701

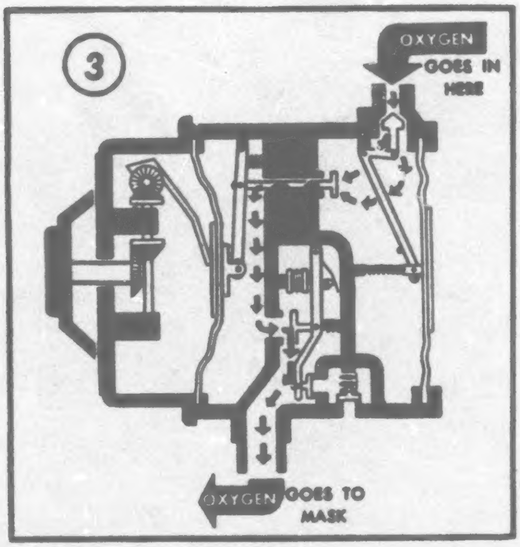
Answers to Frame 5: 1. 0.43 2, 30,000 ft, 39,000 ft 3. 0.21
4. 41M

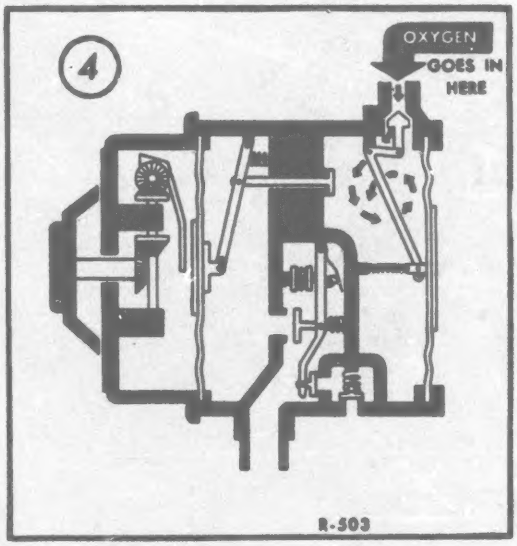
Frame 6

The first schematic below shows operation at sea level. The dial would be set at "NORMAL." Anytime that the regulator is not being used it must be set on "NORMAL" or else spring tension on the demand diaphragm will drain the system. Study all of the schematics and read the information that tells just what is taking place.

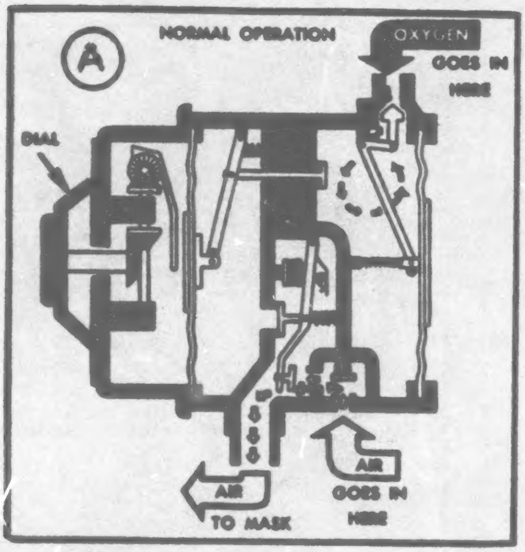

①
NORMAL OPERATION
OXYGEN
GOES IN HERE
DIAL
AIR
GOES IN HERE
AIR
TO MASK

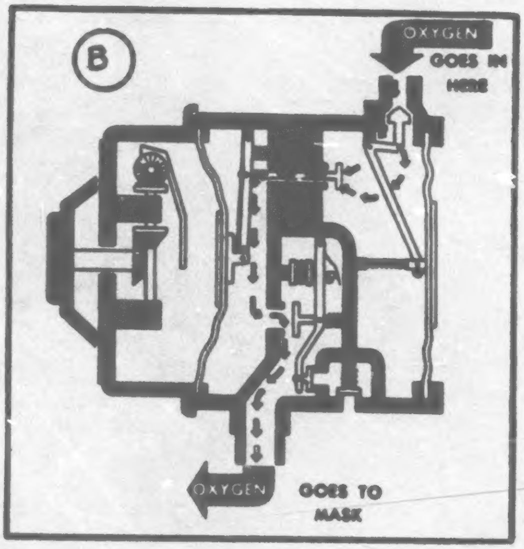

②
OXYGEN
GOES IN HERE
OXYGEN
GOES TO MASK


③
OXYGEN
GOES IN HERE
OXYGEN
GOES TO MASK


④
OXYGEN
GOES IN HERE
R-503

No Response Required


A
NORMAL OPERATION
OXYGEN
GOES IN HERE
DIAL
AIR
GOES IN HERE
AIR
TO MASK


B
OXYGEN
GOES IN HERE
OXYGEN
GOES TO MASK

Place the letter of the sketch in the blank space next to the situation it matches.

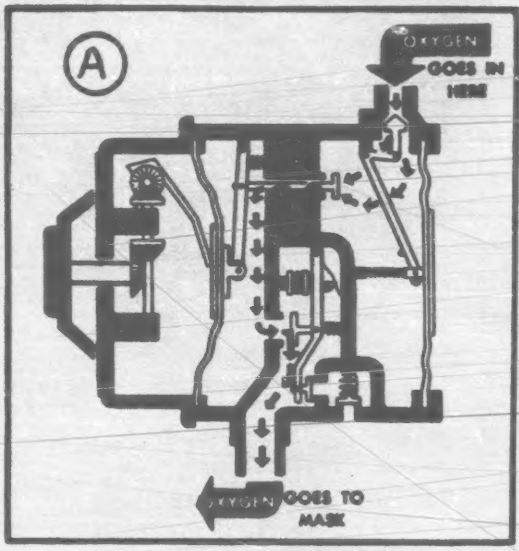
_____1. You will only breathe air because the air valve is open and the oxygen valve is closed.

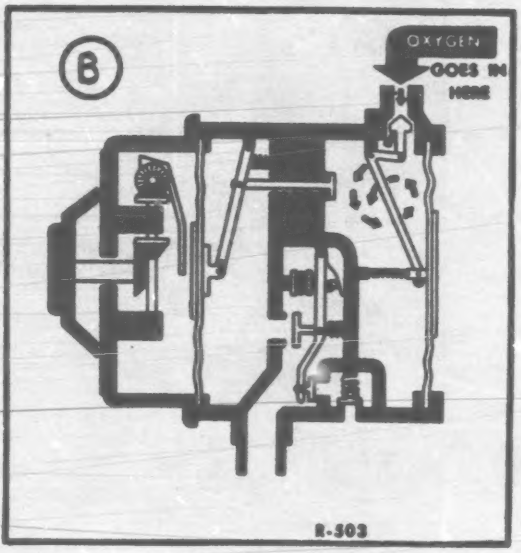
_____2. The regulator will provide you with 100% oxygen because the air valve is closed and the oxygen valve is open.

3703

Answers to Frame 7: 1. A 2. B

Frame 8


A
OXYGEN
GOES IN HERE
OXYGEN GOES TO MASK


B
OXYGEN
GOES IN HERE
R-503

Place the letter of the sketch in the blank space next to the situation it matches.

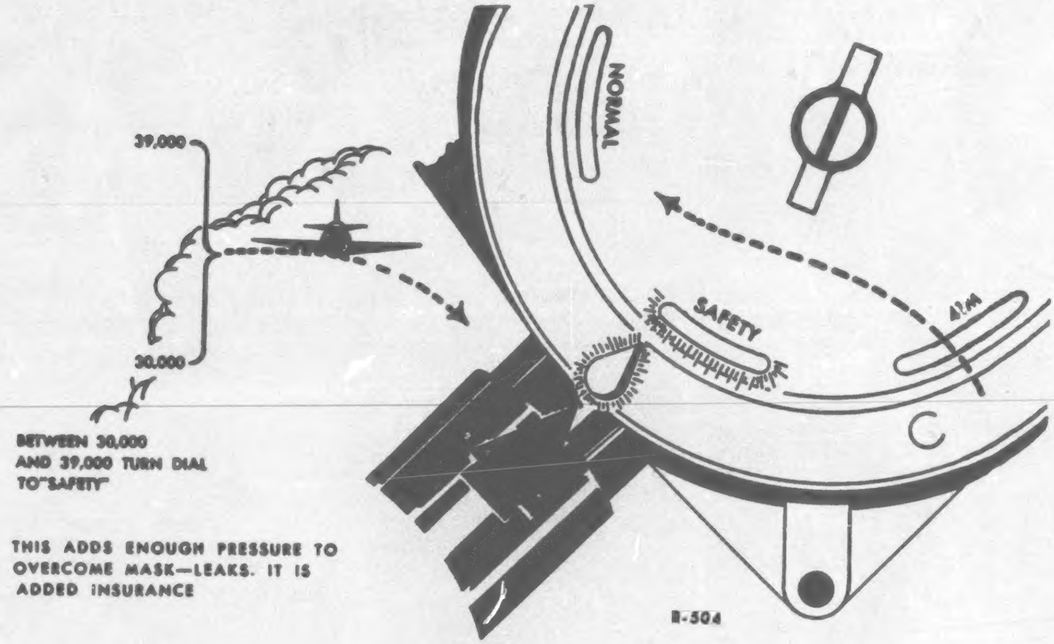
_____1. As you breathe out you push the diaphragm against the spring tension. This in turn closes the demand valve and stops the flow of oxygen to the mask.

_____2. When you inhale the spring pushes against the diaphragm. The diaphragm opens the demand valve and oxygen is forced into the mask.

Answers to Frame 8: B 1. A 2.

Frame 9

As has been said, the "normal" setting on the A-14 is used up to 30,000 feet and when the system is not being used the regulator must be left in this position. From 30,000 feet to 39,000 feet, the user should select the SAFETY setting on the dial. As explained below, this is added insurance against hypoxia which can creep up on you. The SAFETY setting provides only .04 psi to the mask.



BETWEEN 30,000 AND 39,000 TURN DIAL TO "SAFETY"

THIS ADDS ENOUGH PRESSURE TO OVERCOME MASK—LEAKS. IT IS ADDED INSURANCE

Use of the Safety Setting on Type A-14 Oxygen Regulators.

Check the following statements that are true.

____1. The SAFETY setting on the A-14 is used between 30,000 and 39,000 feet.

____2. The SAFETY is used in case of an emergency.

____3. Hypoxia can creep up on you at high altitudes.

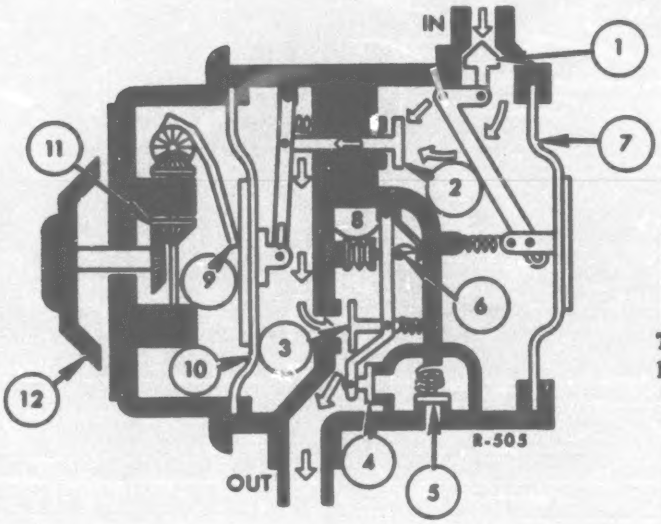
____4. When left in NORMAL, the regulator will not drain the system.

2705

Answers to Frame 9: ✓ 1. ____ 2. ✓ 3. ✓ 4.

Frame 10

Keep in mind that without the pressure breathing mechanism, the A-14 will work the same as the A-12A regulator. The oxygen is reduced in the first stage chamber to 40 to 60 psi by the pressure reducing valve (1) and the diaphragm (7). The demand valve (2) is still controlled by the demand diaphragm just the same as in the A-12A. The oxygen pressure in the second stage chamber can be controlled in two ways. At low altitude it will be the same as the cabin pressure on top of the demand diaphragm and during pressure breathing it will be controlled by the spring tension of the pressure breathing lever (9). Remember, the air for dilution is still controlled by the diluter lever which works the diluter cam (6) and by the aneroid (8).



Type A-14 Pressure Demand Oxygen Regulator.

Place the number(s) of the component in the blank next to the statement that best describes its operation/use.

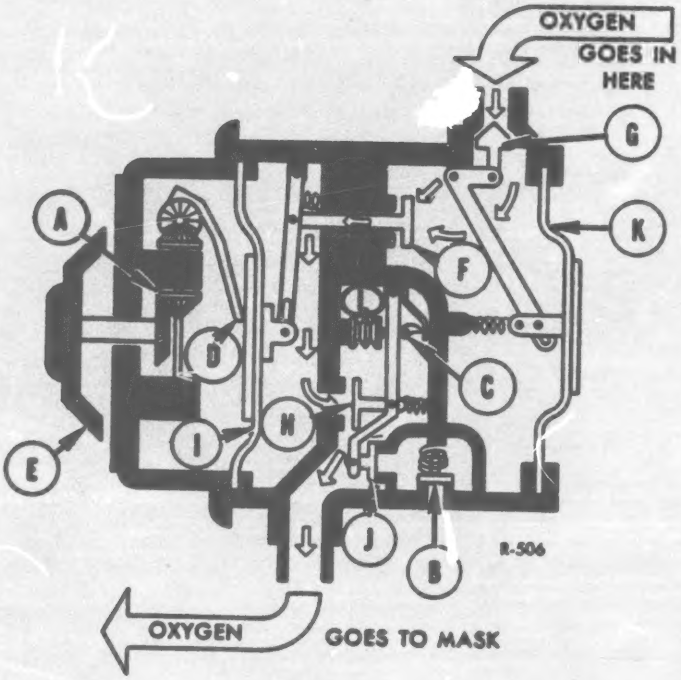
_____a. Controlled by the demand diaphragm.

_____b. Spring tension of this lever will control the oxygen pressure in the second stage chamber during pressure breathing.

_____c. This part and the diluter lever control the air for dilution.

Answers to Frame 10: __2__ a. __9__ b. __8__ c.

Frame 11



Place the letter(s) of the part in the blank space next to the statement that describes its operation/use. Some statements require more than one answer.

_____1. Reduces oxygen pressure in the first stage chamber to 40 to 60 PSI.

_____2. In the 100% oxygen position the diluter control cam presses down on a metal strip attached to a common lever to close this valve.

_____3. When you inhale, this spring puts a force on the demand diaphragm and opens the demand valve.

_____4. The diluter lever works this item.

_____5. This item will control the air flow to the mask up to 32,000 feet with the diluter lever in the normal position.

_____6. Exhaling will force this diaphragm against the spring tension on the pressure breathing lever and close the demand valve.

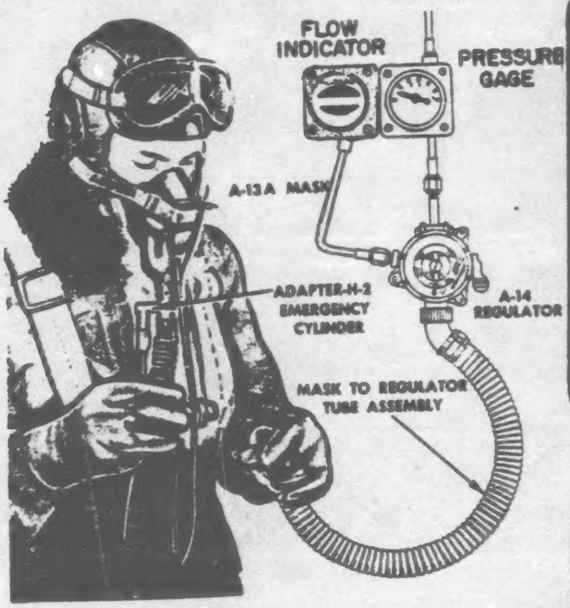
_____7. To breathe 100% oxygen these valves must be open.

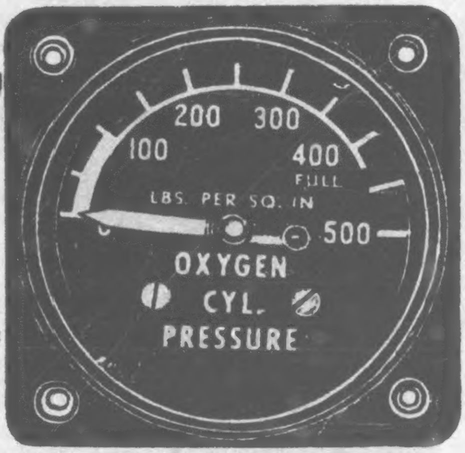
2707

Answers to Frame 11: G, K 1. J 2. D 3. C 4. L 5.
I 6. F, H 7.

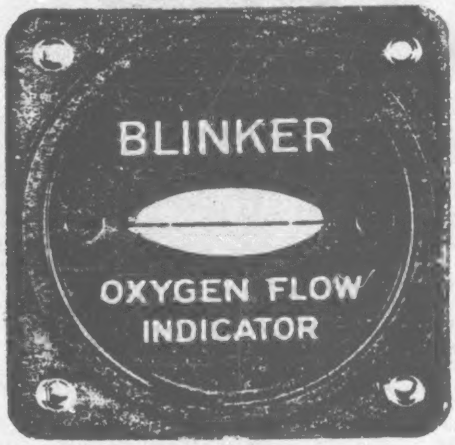
Frame 12

Before we go to the next regulator that has a pressure gage and a flow indicator built in, we should say here that with the A-14, the A-3 flow indicator, and the K-1 pressure gage are the same ones as used with the A-12A. If you recall, in the past lesson we said that the K-1 pressure gage is bourdon tube operated and shows cylinder pressure. The A-3 flow indicator (blinker) lets the user know that oxygen is flowing through the regulator by a blinking action.


FLOW INDICATOR
PRESSURE GAGE
A-13A MASK
ADAPTER-H-2 EMERGENCY CYLINDER
A-14 REGULATOR
MASK TO REGULATOR TUBE ASSEMBLY


100
200
300
400
FULL
500
LBS. PER SQ. IN
OXYGEN
CYL.
PRESSURE

K-1 Pressure Gage.


BLINKER
OXYGEN FLOW
INDICATOR

A-3 Flow Indicator.

Check the following statements that are true.

_____1. The K-1 pressure gage and A-3 flow indicator are used with the A-12A and A-14 regulators.

_____2. All oxygen regulators require a separate pressure gage.

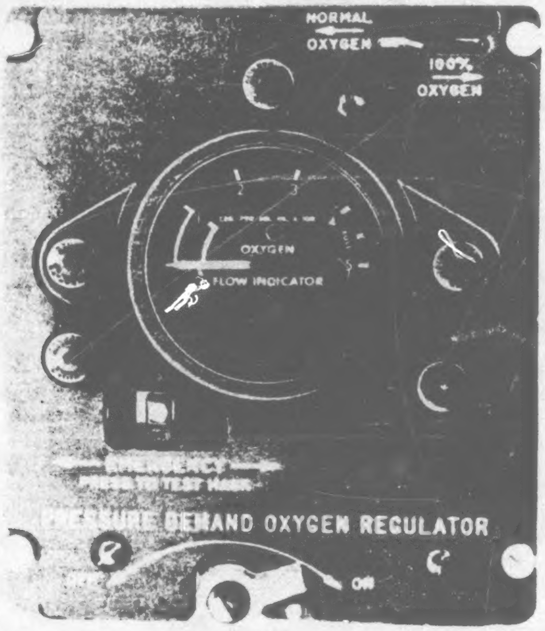
_____3. The K-1 pressure gage is bourdon tube operated.

2708

Answers to Frame 12: ✓ 1. ____ 2. ✓ 3.

Frame 13

As was said in the past, there are many models of that same oxygen regulator. The D-2A regulator, shown below, is also a pressure demand regulator with many changes over the A-14. The change that is most easily seen from looking at the face of the D-2A is that the pressure gage and the flow indicator have been added to it. Now note that no pressure control dial is seen so this shows that the D-2a will automatically deliver the right pressure as altitude changes. This is done with an aneroid. The D-2A regulator also has an ON-OFF supply switch (lower center) that shuts off the oxygen supply to the regulator when it is not being used. The D-2A is placed on a panel in the aircraft and the A-12A and A-14 are hooked in the oxygen lines.



Type D-2A Oxygen Regulator.

Complete the following statements.

1. The D-2A oxygen regulator has a built-in pressure gage and __________ __________.

2. Inside of the D-2A regulator is an __________ that will automatically deliver the right pressure as the altitude changes.

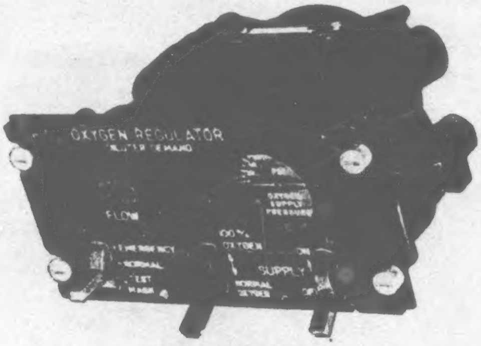
3. The D-2A is mounted __________ __________ __________ in the aircraft while the __________ and __________ are connected into the oxygen line.

2709

Answers to Frame 13: 1. flow indicator 2. aneroid
3. on a panel, A-12A, A-14

Frame 14

The MD-1 pressure demand regulator, shown below, is very much like the D-2A but has a lot of improvements. The compact design needs about half of the panel space to mount in and presents the user with a much more uniform and readable system of controls. This regulator is used more at the present time than any other regulator because it can be adapted to more systems in use. For high altitude flights this is the best regulator available at the present time. In the illustration, look at the three toggle switches that are used to control this regulator. The EMERGENCY toggle (left) has three positions: emergency (up), normal (center), and test mask (down). The DILUTER toggle (center) has two positions: 100% and normal. The SUPPLY toggle is simply on or off. The FLOW indicator is the "flag" type which is worked by a diaphragm. The pressure gage shows system pressure or pressure before it is reduced for breathing.



Type MD-1 Automatic Diluter Demand Pressure
Breathing Oxygen Regulator.

Check the following statements that are true.

_____1. The MD-1 has three toggle switches for control.

_____2. The MD-1 is used more than other regulators at present.

_____3. The MD-1 is twice as large as the D-2A regulator.

_____4. The emergency toggle has three positions.

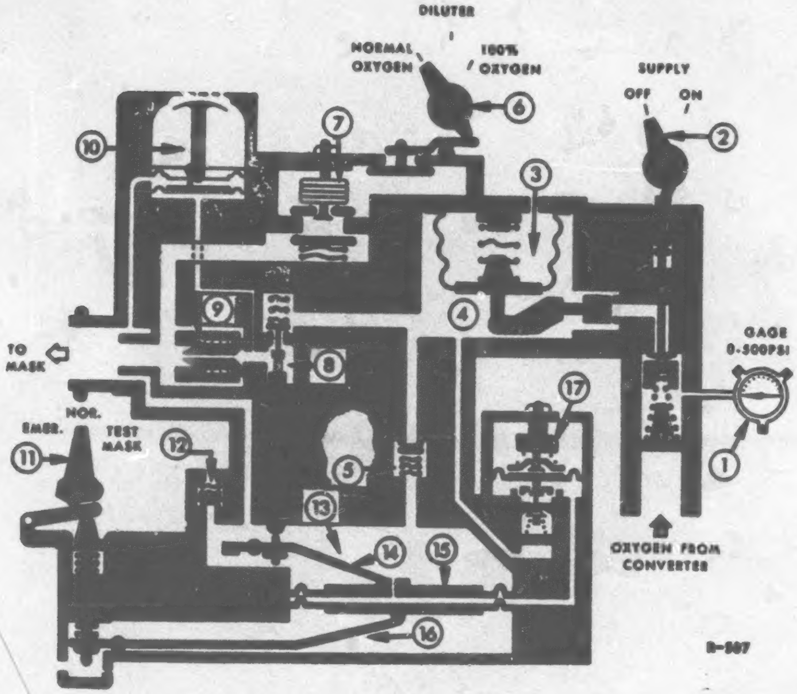
_____5. The flow indicator operates from a diaphragm.

2710

Answers to Frame 14: ✓ 1. ✓ 2. ____ 3. ✓ 4. ✓ 5.

Frame 15

Let's take a look at the major parts inside the MD-1 before we talk about how it operates. Mentally match each numbered item in the schematic below with its name from the list below.


DILUTER
NORMAL OXYGEN
100% OXYGEN
SUPPLY
OFF
ON
⑥
②
⑦
⑩
③
④
⑨
⑧
TO MASK
GAGE 0-500PSI
NOR.
EMER.
TEST MASK
⑪
⑫
⑰
⑤
⑬
①
⑭
⑮
OXYGEN FROM CONVERTER
⑯
B-987

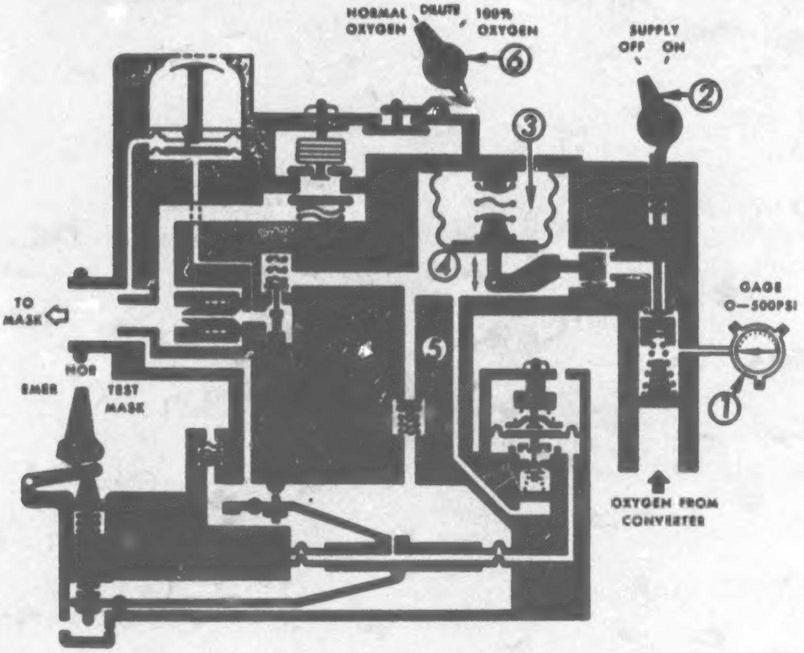
1. Pressure Gage
2. Supply Toggle
3. Press. Reducing Mechanism
4. 1st Stage Chamber
5. 1st Stage Relief Valve
6. Diluter Toggle
7. Diluter Aneroid
8. Demand Valve
9. Injector Mechanism
10. Flow Indicator
11. Emergency Toggle
12. 2nd Stage Relief Valve
13. 2nd Stage Chamber
14. Demand Valve Lever
15. Demand Diaphragm
16. Counter-Weight Lever
17. Press. Breathing Aneroid

No Response Required

7711

Frame 16

Some of the parts of the MD-1 have, in the past, been pointed out to you. The pressure gage (1) shows system (or supply) pressure. The supply toggle switch (2) just lets oxygen in the regulator when it is placed in "ON." The pressure reducing mechanism (3) is the first stage of reducing. This is a spring loaded bellows and valve which sets the incoming pressure between 37 and 45 psi. As the bellows moves up and down, the valve moves back and forth (see arrows). The reducing mechanism is in the first stage chamber (4). The first relief valve (5) will open at 55 psi if the reducing mechanism fails. The diluter toggle switch (6) lets cabin air in to mix with the oxygen when it is in the "normal oxygen" position and the air inlet valve is in the "100% oxygen" position.



Match the circled number of the component in the schematic to the statement below that describes that component operation/use.

_____a. Opens a valve that allows oxygen from a converter into the regulator.

_____b. When put into the normal position it lets cabin air mix with the oxygen and dilute it.

_____c. A high incoming oxygen pressure will affect a spring-loaded bellows in this mechanism which in turn will set the incoming pressure between 37 to 45 psi.

_____d. A spring loaded valve that will open at 55 psi if the pressure reducing valve failed.

_____e. Shows the oxygen pressure in the system (supply pressure).

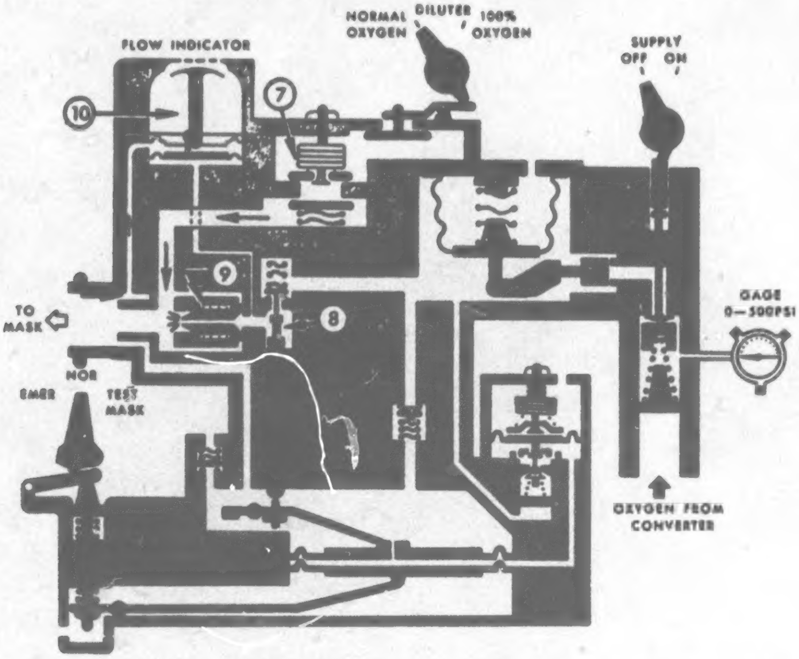
93

2712

Answers to Frame 16: 2 a. 6 b. 3 c. 5 d. 1 e.

Frame 17

The diluter aneroid (7) lets air in according to the cabin altitude when the diluter toggle switch is in the "normal oxygen" position. The aneroid will expand and completely shut off the air at 33,000 feet cabin altitude. The demand valve (8) lets the oxygen into the injector assembly (9) which acts as a venturi (creates a low pressure area). This low pressure area draws air in to mix with the oxygen. If a large demand is placed on the regulator, the injector (9) will slide forward (to the left) and let oxygen bypass through the passageway on each side. The flow indicator (10) is a "flag" which is diaphragm-operated and shows in the viewing window as the user breathes.



Place the number of the component from the above schematic in the blank alongside the statement that best describes its operation/use. Some numbers can be used more than once.

_____a. Cabin atmospheric pressure will cause this unit to expand.

_____b. Creates a low pressure area that draws air in to mix with the oxygen.

_____c. The amount of oxygen that flows into the injector is controlled by this unit.

_____d. Meters air according to the cabin altitude completely shutting off the air flow when the cabin altitude reaches 33,000 feet.

_____e. Operated by a diaphragm to show the flow of oxygen each time the user inhales.

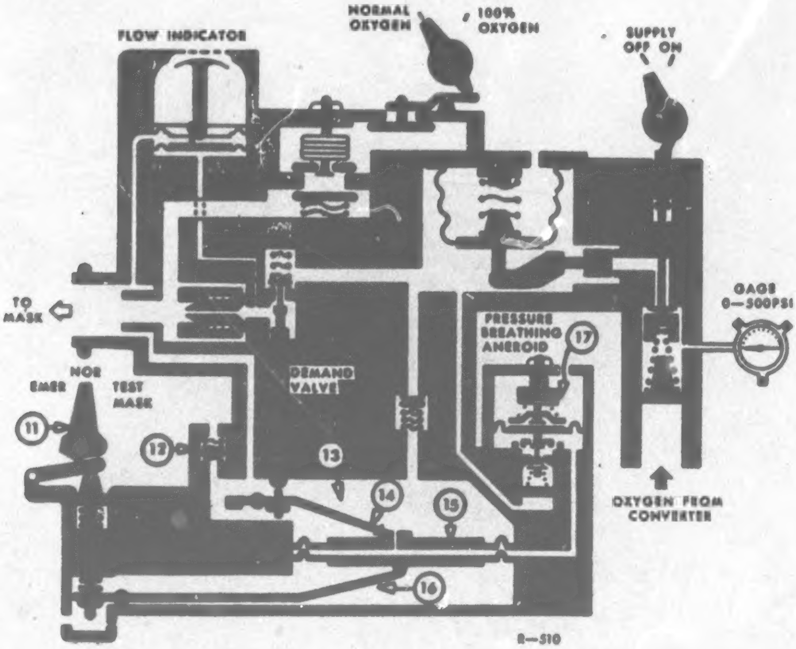
_____f. Slides forward when a high demand is placed on the regulator to let oxygen bypass through passageways in each side of it.

2713

Answers to Frame 17: 7 a. 9 b. 8 c. 7 d. 10 e. 9 f.

Frame 18

The emergency toggle switch (11) gives pressure breathing at any altitude when it is put in "EMER." In the n"normal" position, pressure breathing is taken care of by the pressure breathing aneroid (17). The "test mask" position provides pressure for testing the mask for leaks while on the face. The second stage relief valve (12) relieves pressure above 1.5 inches of water pressure in the second stage chamber (13). The demand valve lever (14) is hooked, at one end, to the demand diaphragm. It will push the demand valve found on the other end of the lever up and down. The counterweight lever (16) provides a linkage to the emergency toggle switch. It stops the fluctuation of pressure in the second stage chamber. The pressure breathing aneroid (17), which was mentioned earlier, automatically increases the pressure load on the demand diaphragm as the aircraft altitude increases. This, in turn, increases the pressure sent to the mask.


NORMAL OXYGEN
100% OXYGEN
FLOW INDICATOR
SUPPLY
OFF ON
TO MASK
GAGE 0—500PSI
PRESSURE BREATHING ANEROID
17
NOR
EMER
TEST MASK
DEMAND VALVE
11
12
13
14
15
16
OXYGEN FROM CONVERTER
R—510

Place the number of the part from the above sketch in the blank space alongside the statement that best describes its operation/use. Some numbers can be used more than once.

_____a. In the normal position aircraft altitude will cause this unit to expand and increase the pressure load on the demand diaphragm which, in turn, will increase the pressure sent to the mask.

_____b. Provides a linkage from the demand diaphragm to the emergency toggle switch.

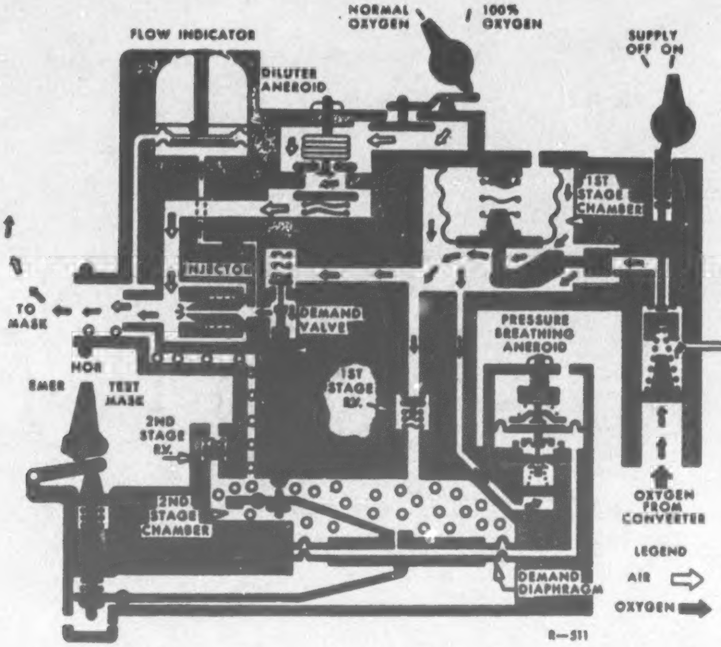
_____c. When moved by the demand diaphragm, moves the demand valve up or down to increase or decrease the pressure sent to the mask.

_____d. When placed in the emergency position it will provide pressure breathing at any altitude

Answers to Frame 18: 17 a. 16 b. 14 c. 11 d.

Frame 19

In the sketch shown you can see how the MD-1 works below 30,000 feet when the user inhales or calls for oxygen. Follow the flow of oxygen and air through the regulator as we talk about how it works. With the supply toggle switch "ON," oxygen goes to the first stage chamber where the pressure is dropped to 37 to 45 psi. Oxygen now goes down to the small chamber below the pressure breathing aneroid. The aneroid has not expanded and the diaphragm under the aneroid has this port closed. When the user inhales, a vacuum is formed in the second stage chamber (shown by the circles) that will raise the demand diaphragm and the demand lever which, in turn, opens the demand valve. Oxygen will now flow through the top of the demand valve and through the injector, which will cause a low pressure area and draw in air from around the diluter aneroid. Oxygen also goes up to the flow indicator diaphragm and pushes the flag up to the window. The air and oxygen now mix in front of the injector and flow to the mask.


NORMAL OXYGEN
100% OXYGEN
FLOW INDICATOR
SUPPLY
OFF ON
DILUTER ANEROID
1ST STAGE CHAMBER
INJECTOR
TO MASK
DEMAND VALVE
PRESSURE BREATHING ANEROID
PRESSURE GAGE 0—500PSI
NOR
EMER
TEST MASK
2ND STAGE R.V.
1ST STAGE R.V.
2ND STAGE CHAMBER
OXYGEN FROM CONVERTER
LEGEND
AIR ⇨
OXYGEN ➡
DEMAND DIAPHRAGM
R—511

Select the statements that describe the operation of the MD-1 oxygen regulator. (Circle the number(s) of your choice.)

1. As you inhale the demand diaphragm will rise and open the demand valve and let oxygen from the converter flow through the injector.

2. The oxygen that flows through the injector will create a low pressure area that will draw in air from around the diluter aneroid and mix it with the oxygen.

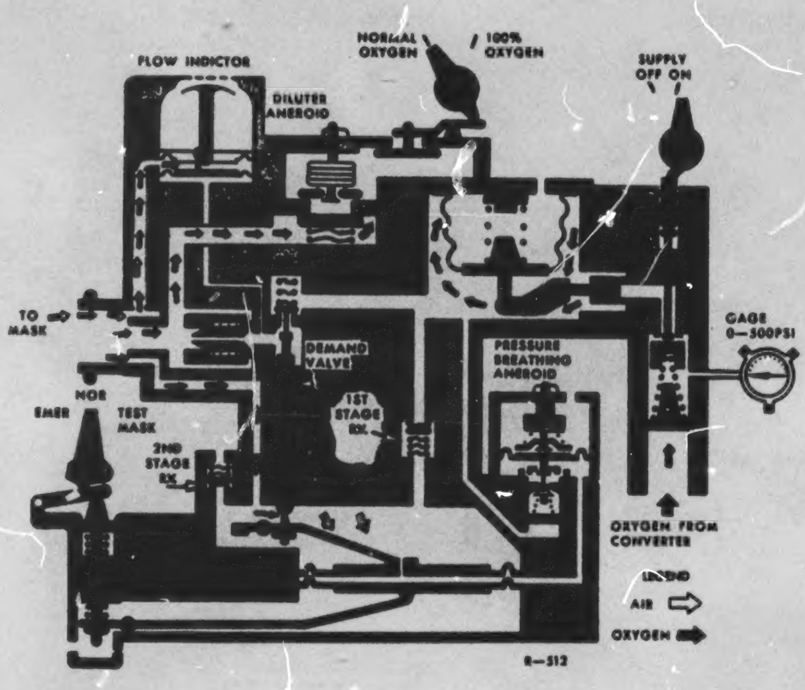
3. For items 1 and 2 above to happen the supply toggle is in the "ON" position, diluter toggle is in "normal oxygen," the emergency toggle is in "NOR," and the aircraft must be below 30,000 feet.

2715

Answers to Frame 19: ① ② ③

Frame 20

Let's take a look at what goes on in the regulator when the user exhales or breathes out. Muscular effort on the part of the user is needed to overcome the pressure in the regulator. This is especially true if the pressure breathing aneroid is in operation. When the user breathes out hard enough, the demand diaphragm drops down and lets the demand valve go closed. This back pressure also closes the air check valve below the diluter aneroid. Pressure on the top side of the flow indicator diaphragm pulls the flag out of the window. Oxygen pressure will quickly build up in the first stage chamber and close the reducing valve. When the user inhales again, this pressure is reversed as was explained in the previous frame.


FLOW INDICTOR
DILUTER ANEROID
NORMAL OXYGEN
100% OXYGEN
SUPPLY OFF ON
TO MASK
DEMAND VALVE
1ST STAGE RX
PRESSURE BREATHING ANEROID
GAGE 0—500PSI
NOR
EMER
TEST MASK
2ND STAGE RX
OXYGEN FROM CONVERTER
LEGEND
AIR
OXYGEN
R—512

Select the true statements from the following. (Circle the number(s) of your choice.)

1. When the user exhales, the flow indicator flag is not visible.

2. Muscular effort is required when exhaling into the regulator.

3. When exhaling, the demand diaphragm drops and closes the demand valve.

4. The diluter toggle must be in 100% oxygen to get air in the regulator.

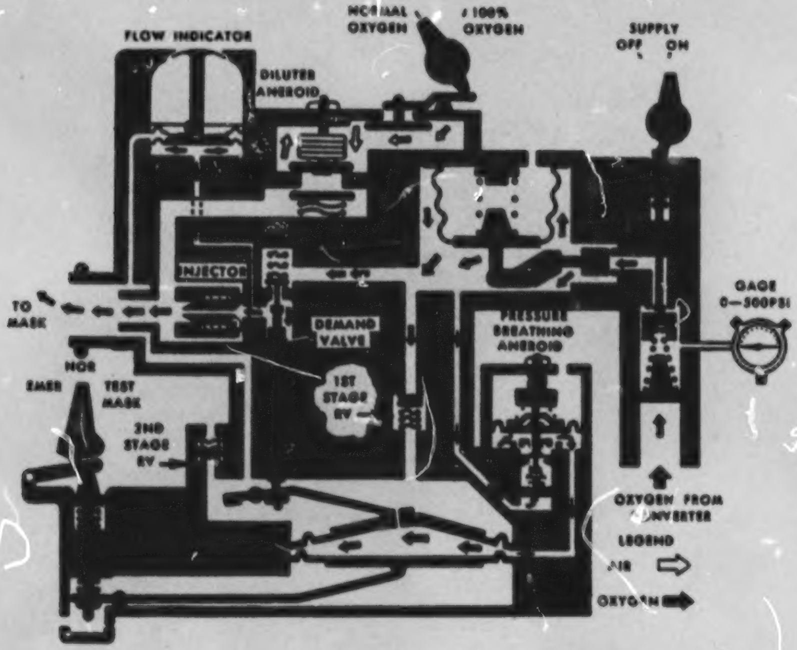
5. The first-stage chamber reduces pressure to between 37 and 45 psi.

2716

Answers to Frame 20: [✓ 1.] [✓ 2.] [✓ 3.] 4. [✓ 5.]

Frame 21

Now, let's talk on how the MD-1 regulator works when pressure breathing. As we have said, pressure to the mask is changed automatically by the pressure breathing aneroid as cabin pressure goes up. A safety pressure of 0.1 to 0.2 inches of water is sent to the mask at altitudes of 30,000 to 39,500 feet to do away with the chance of a negative pressure at the mask. Near 40,000 feet, the pressure breathing aneroid has expanded to give automatic pressure breathing to the user. This pressure is from 2 to 15 inches of water pressure depending on cabin altitude. You can see in the sketch shown that oxygen from the pressure breathing aneroid has raised the demand diaphragm which now holds the demand valve open. The cycle shown is when the user is breathing in. To exhale, the user has to overcome the pressure on the demand diaphragm. See, too, that the diluter aneroid has closed the air inlet and the flow indicator flag can be seen in the window.


FLOW INDICATOR
DILUTER ANEROID
NORMAL OXYGEN
100% OXYGEN
SUPPLY
OFF ON
INJECTOR
TO MASK
DEMAND VALVE
PRESSURE BREATHING ANEROID
GAGE 0—500PSI
NOR
EMER
TEST MASK
1ST STAGE RV
2ND STAGE RV
OXYGEN FROM CONVERTER
LEGEND
AIR ⇨
OXYGEN ➡

1—813

Select the statements that describe the operation of the MD-1 regulator during pressure breathing. (Circle the number(s) of your choice.)

1. At altitudes of 30,000 to 39,500 feet a safety pressure of 0.1 to 0.2 inches of water is sent to the mask to do away with the chance of a negative pressure at that point.

2. Around 40,000 feet the pressure breathing aneroid has expanded and raised the demand diaphragm which, in turn, holds the demand valve open.

3. To exhale you have to overcome the pressure applied to the demand diaphragm.

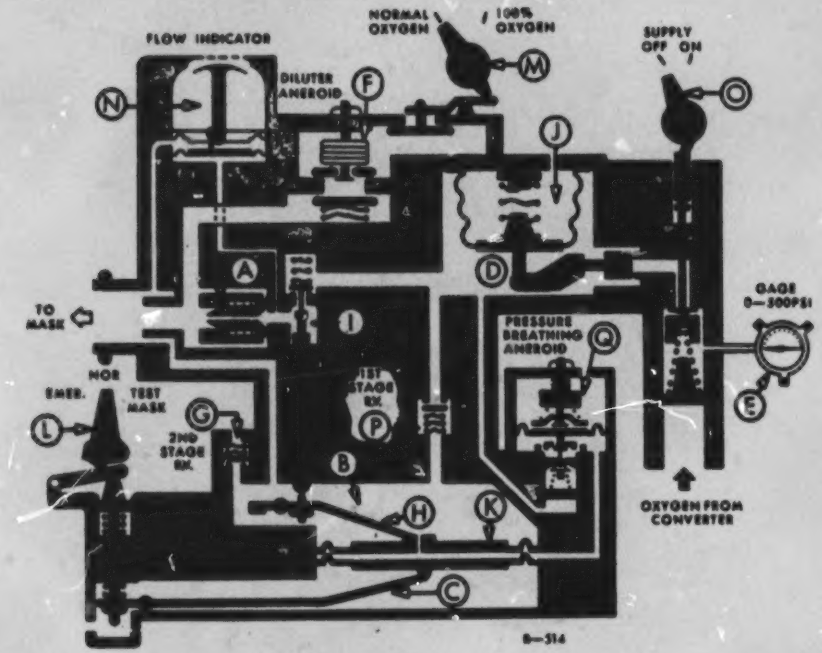
2717

Answers to Frame 21: ① ② ③

Frame 22

INSTRUCTIONS

Identify the components of the MD-1 oxygen regulator by matching the letters in the arrowed circles with the name of the item below.


FLOW INDICATOR
NORMAL OXYGEN
100% OXYGEN
SUPPLY
OFF ON
DILUTER ANEROID
M
F
N
O
J
A
D
I
TO MASK
GAGE 0—500PSI
PRESSURE BREATHING ANEROID
Q
NOR
EMER.
TEST MASK
L
G
2ND STAGE RX.
1ST STAGE RX.
P
B
E
H
K
C
OXYGEN FROM CONVERTER
8—314

_____1. Pressure Gage
_____2. Supply Toggle
_____3. Pressure Reducing Mechanism
_____4. 1st Stage Chamber
_____5. 1st Stage Relief Valve
_____6. Diluter Toggle
_____7. Diluter Aneroid
_____8. Demand Valve
_____9. Injector Mechanism

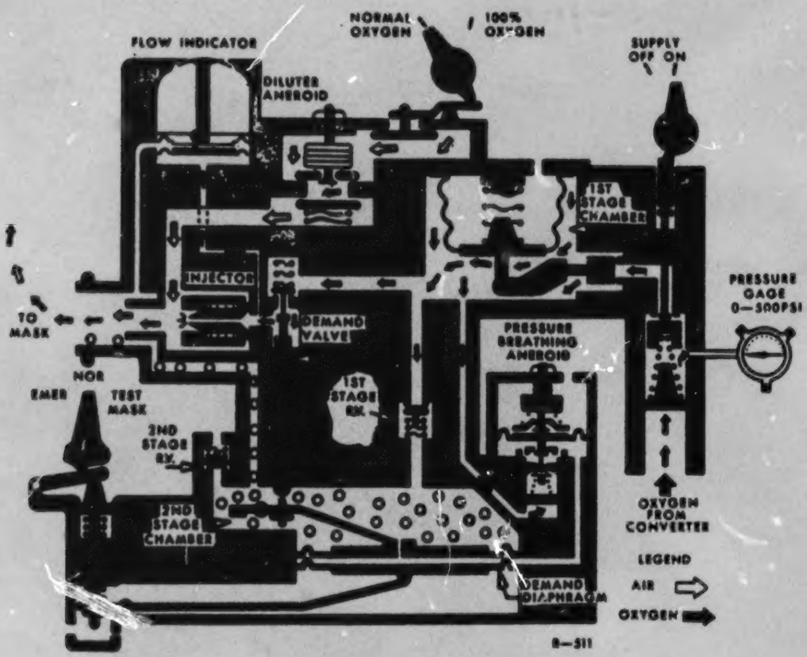
____10. Flow Indicator
____11. Emergency Toggle
____12. 2nd Stage Relief Valve
____13. 2nd Stage Chamber
____14. Demand Valve Lever
____15. Demand Diaphragm
____16. Counter-Weight Lever
____17. Pressure Breathing Aneroid

99

Answers to Frame 22:

E 1. O 2. J 3. D 4. P 5.
M 6. F 7. I 8. A 9. N 10.
L 11. G 12. B 13. H 14. K 15.
C 16. Q 17.

Frame 23


FLOW INDICATOR
NORMAL OXYGEN
100% OXYGEN
SUPPLY
OFF ON
DILUTER ANEROID
1ST STAGE CHAMBER
INJECTOR
DEMAND VALVE
PRESSURE GAGE 0—500PSI
TO MASK
PRESSURE BREATHING ANEROID
NOR
EMER
TEST MASK
1ST STAGE RV.
2ND STAGE RV.
2ND STAGE CHAMBER
OXYGEN FROM CONVERTER
LEGEND
AIR
OXYGEN
DEMAND DIAPHRAGM
8—511

Select the statements that describe the operation of the MD-1 regulator below 30,000 feet. (Circle the number(s) of your choice.)

1. Both the pressure breathing aneroid and diluter aneroid are compressed.

2. The pressure breathing aneroid expands while the diluter aneroid is compressed.

3. With the supply toggle in "ON," oxygen goes to the first stage chamber where it is reduced to 37 to 45 psi.

4. When you inhale a vacuum is formed in the second stage chamber that raises the demand diaphragm and opens the demand valve.

5. Oxygen will flow through the injector which creates a low pressure area that draws air in through the diluter aneroid valve.

6. Both the oxygen from the injector and the air from the diluter aneroid mix and flow to the mask.

7. As you inhale a pressure is placed on the demand diaphragm forcing the demand diaphragm to close the demand valve.

8. As you inhale a pressure is placed on the top of the flow indicator diaphragm which pulls the flag out of the window.

2719

Frame 23 (Cont'd)

Select the statements that describe the operation of the MD-1 regulator during pressure breathing. (Circle the number(s) of your choice.)

9. The diluter aneroid will expand as the aircraft rises in altitude closing the diluter valve.

10. The diluter aneroid will send a safety pressure of 0.1 to 0.2 inches of water to the mask at altitudes of 30,000 to 39,000 feet.

11. Near 40,000 feet, the pressure breathing aneroid has expanded and provides oxygen pressure to the mask equivalent to 2 to 15 inches of water pressure.

12. The pressure breathing aneroid supplies oxygen pressure to raise the demand diaphragm and close the demand valve.

13. During pressure breathing a person cannot exhale.

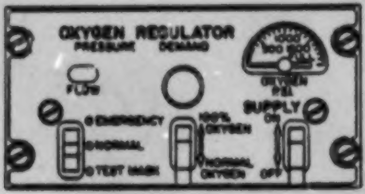
14. When oxygen pressure is supplied to the mask it also is placed on the bottom of the flow indicator diaphragm raising the flag in the window.

2720

Answers to Frame 23: [✓ 1.] 2. [✓ 3.] [✓ 4.] [✓ 5.] [✓ 6.] 7. 8.
[✓ 9.] 10. [✓ 11.] 12. 13. [✓ 14.]

Frame 24

The oxygen regulators that are used in high pressure gaseous oxygen systems (1,800 to 1,850 psi) where a pressure reducer _is not_ installed between the cylinders and the regulator are the MD-2 and MB-2 pressure demand regulators. If a pressure reducer _is_ installed, regulators such as the MD-1 and D-2A can be used. The principles of operation of the MD-2 and MB-2 are the same as the MD-1. However, these regulators are constructed internally to withstand high pressure. The MD-2 shown (note the high pressure gage) looks the same as the MD-1 but the two regulators _cannot_ be interchanged.


OXYGEN REGULATOR
PRESSURE DEMAND
FLOW
OXYGEN
PSI
SUPPLY
ON
OFF
EMERGENCY
NORMAL
TEST MASK
100%
OXYGEN
NORMAL
OXYGEN

MD-2 Oxygen Regulator

Check the following statements that are _true_.

_____1. The MD-2 and MB-2 are high-pressure regulators.

_____2. The D-2A regulator is designed to withstand high pressure.

_____3. The MD-2 is a pressure demand regulator.

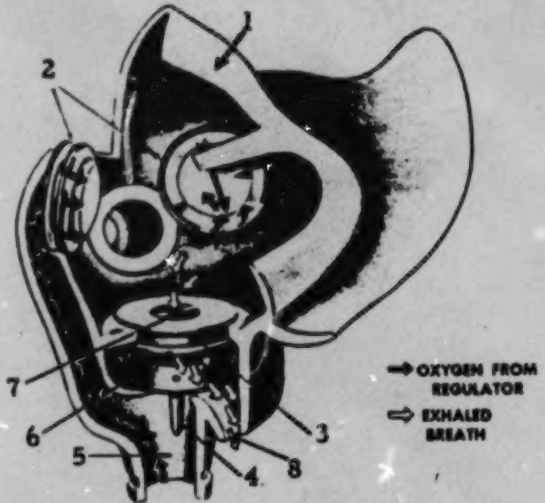
_____4. If a pressure reducer is installed between the high pressure cylinders and the regulator, it's possible to use the D-2A.

2721

Answers to Frame 24: _✓_1. ____2. _✓_3. _✓_4.

Frame 25

The pressure demand mask, type A-13 and type A-13A, are used with the pressure demand oxygen system. Pressure demand masks are not like demand masks in that they will hold pressures higher than ambient pressure. A flap or seal made of rubber (1) forms a ring on the inside of the mask to keep the oxygen in the mask. Check valves (2) keep the oxygen inlets closed while the user is exhaling. The exhalation valve (3) opens only at a pressure just a little more than that on the inside of the tubing leading to the mask. The housing of the exhalation valve forms a tube which goes down into the inlet tube (5). Through this tube, the oxygen coming in sends its delivery pressure to act upon the lower side of the compensating diaphragm (6). This pressure keeps the exhalation valve (3) closed until a little greater pressure caused by exhaling is brought to bear upon the upper surface of the main diaphragm (7). The valve then opens and the exhaled air leaves the mask through the port (8). The mask-to-regulator hose in the pressure demand system is the same as in the demand system.



Type A-13 Pressure Demand Mask.

Place the number from the sketch shown above in the blank alongside the statement that best describes the mask's operation/use.

_____a. Will open when the user inhales and closes when the user exhales.

_____b. Will stay closed until a little greater pressure caused by exhaling is placed on the upper surface of the main diaphragm at which time it will open.

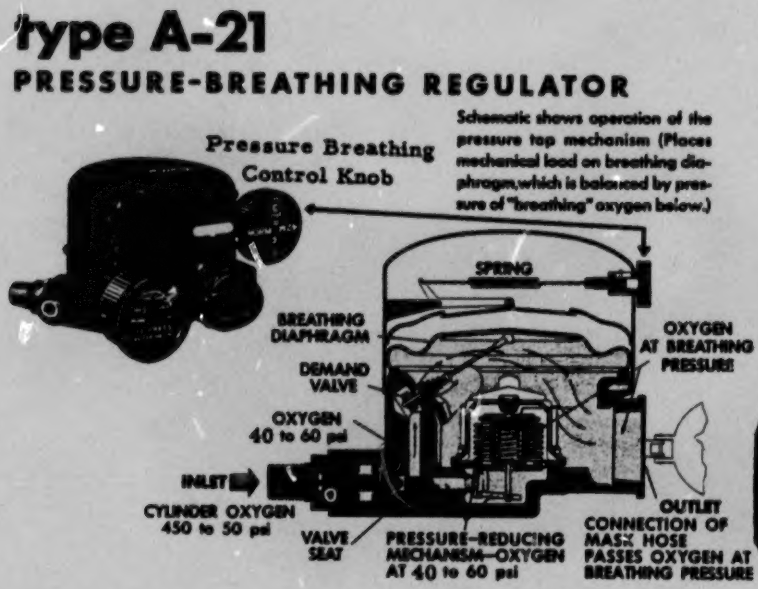
_____c. Exhaled air will leave through this port.

Answers to Frame 25: __2__a. __3__b. __8__c.

2722

Frame 26

The portable pressure demand unit is shown below. It consists of the A-21 regulator and the A-6 cylinder. The pressure demand unit is installed in the larger aircraft with an operating range above 35,000 feet. The A-21 is a straight demand regulator (no air) and contains a bellows-operated pressure reducer. Pressure breathing is caused by turning the control knob which puts a load on the breathing diaphragm through a system of springs and levers (very much like the A-14). The control knob has four (4) settings: "NORMAL" (demand only, no pressure), "30M" (pressure breathing at 30,000 feet), "42M" (pressure breathing at 42,000 feet), and "EMERGENCY" (continuous flow of oxygen to the user).


type A-21
PRESSURE-BREATHING REGULATOR
Pressure Breathing Control Knob
Schematic shows operation of the pressure tap mechanism (Places mechanical load on breathing diaphragm, which is balanced by pressure of "breathing" oxygen below.)
SPRING
BREATHING DIAPHRAGM
DEMAND VALVE
OXYGEN 40 to 60 psi
INLET
CYLINDER OXYGEN 450 to 50 psi
VALVE SEAT
PRESSURE-REDUCING MECHANISM—OXYGEN AT 40 to 60 psi
OXYGEN AT BREATHING PRESSURE
OUTLET CONNECTION OF MASK HOSE PASSES OXYGEN AT BREATHING PRESSURE

BREATHING
OXYGEN

Pressure Demand Portable Unit

Check the following statements that are true.

_____1. The A-21 is a pressure demand portable regulator.

_____2. The A-6 cylinder is used with the A-21 regulator.

_____3. Pressure breathing is controlled by an aneroid in the A-21.

Answers to Frame 26: __✓__1. __✓__2. _____3.

104

2723

PROGRAMMED TEXT
3ABR42331-PT-401D

Technical Training

Aircraft Environmental Systems Mechanic

CONTINUOUS FLOW OXYGEN EQUIPMENT

16 September 1977

3350 TECHNICAL TRAINING WING
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

2724

FOREWORD

This programmed text was prepared for use in the 3ABR42331 Instructional System. The material contained herein has been validated using students enrolled in the 3ABR42331 course. Ninety percent of the students taking this text achieved or surpassed the criteria called for in the lesson objective. The average student required 1 hour and 15 minutes to complete this text.

OBJECTIVE

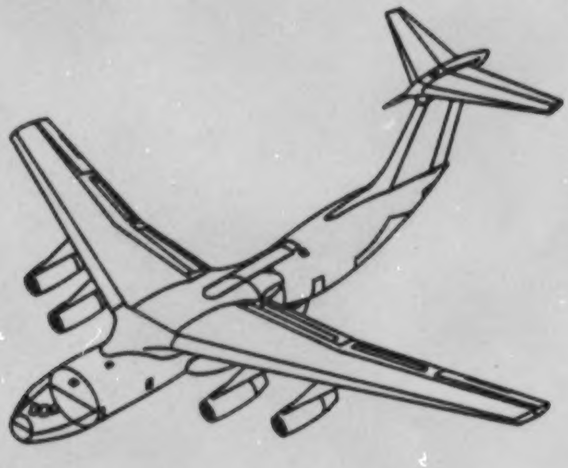
Relate five of six gaseous oxygen system components to its operation.

INSTRUCTIONS

This text presents material in small steps called "frames." After each frame you will find a number of statements and you are asked to select the true statement or statements from this list. Read the material carefully before making a selection. The answers to the statements can be found on the top of the next frame. If you select the correct answers, continue to the next frame. If you are wrong or in doubt, read the material again and correct yourself before continuing.

Supersedes 3ABR42231-PT-313B, 2 December 1970.
OPR: 3370 TTG
DISTRIBUTION: X
3370 TTGTC - 600; TTVSR - 1

Continuous flow or constant flow oxygen equipment is not used in any of the combat type aircraft, but it is used in some of the training aircraft, and in all cargo aircraft that take part in air evacuation and the transporting of troops and cargo. The crew which is in the front part of the aircraft uses the demand type oxygen regulator, while the cargo part in the rear of the aircraft uses the constant flow system. The main reason for this is that the constant flow system does not meet the needs of the crew. The supply for the constant flow system is the same as it is for the demand system, either the gaseous or the liquid may be used. Since there are many constant flow systems that are now in use, this text will be limited to the one that is found on transport or cargo aircraft and is called "THE TROOP OXYGEN SYSTEM."



— Check the following statements that are true.

_____1. Constant flow systems are not used in combat aircraft.

_____2. Constant flow systems use only a gaseous oxygen supply.

_____3. There are many different constant flow systems.

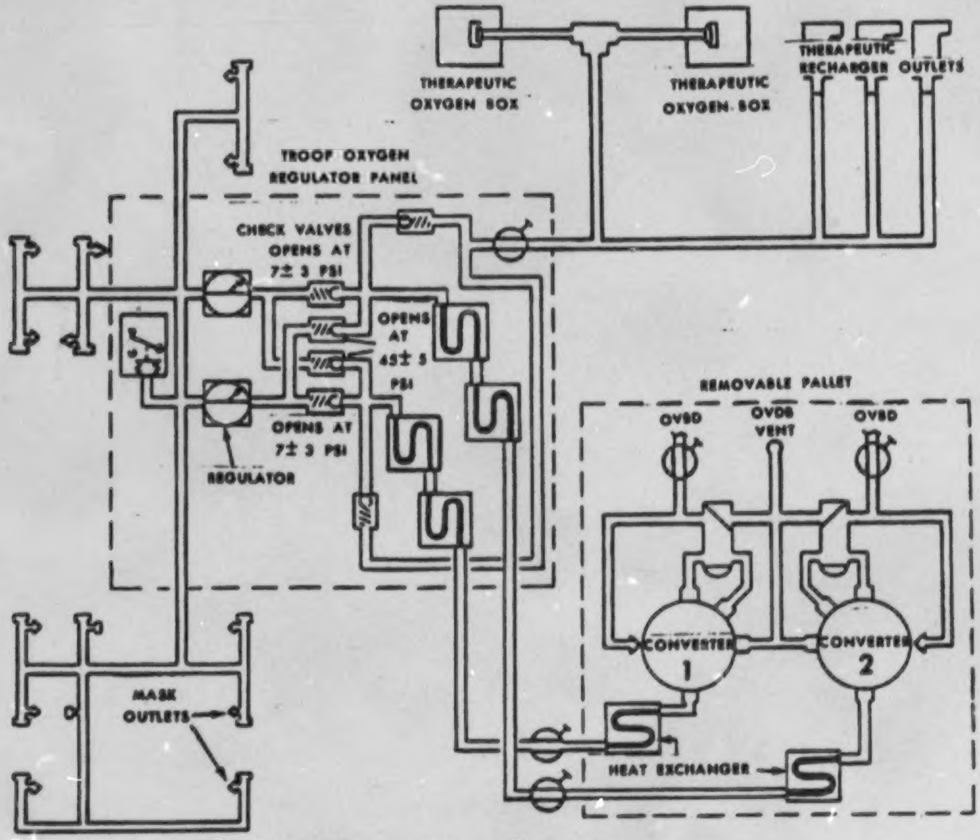
_____4. The constant flow system in transport or cargo aircraft is the troop oxygen system.

2726

Answers to Frame 1: ✓ 1. ____ 2. ✓ 3. ✓ 4.

Frame 2

The troop oxygen system will supply oxygen for up to 154 troops. It will work at a supply pressure of 300 psi. The pressure regulator is used to regulate the distribution pressure from 29 psi to 69 psi, depending on how high the aircraft is flying. If the aircraft is at a low altitude, a strong flow of oxygen will be needed due to the high atmospheric pressure that's around the lungs. The troop system is made up of a pallet that is removable and an oxygen regulator panel. Look at the schematic that is on this page. This will show the items in the system that are going to be covered in this text.


THERAPEUTIC OXYGEN BOX
THERAPEUTIC OXYGEN BOX
THERAPEUTIC RECHARGER OUTLETS
TROOP OXYGEN REGULATOR PANEL
CHECK VALVES OPENS AT 7± 3 PSI
OPENS AT 45± 5 PSI
OPENS AT 7± 3 PSI
REGULATOR
REMOVABLE PALLET
OVBD
OVBD VENT
OVBD
CONVERTER 1
CONVERTER 2
HEAT EXCHANGER
MASK OUTLETS

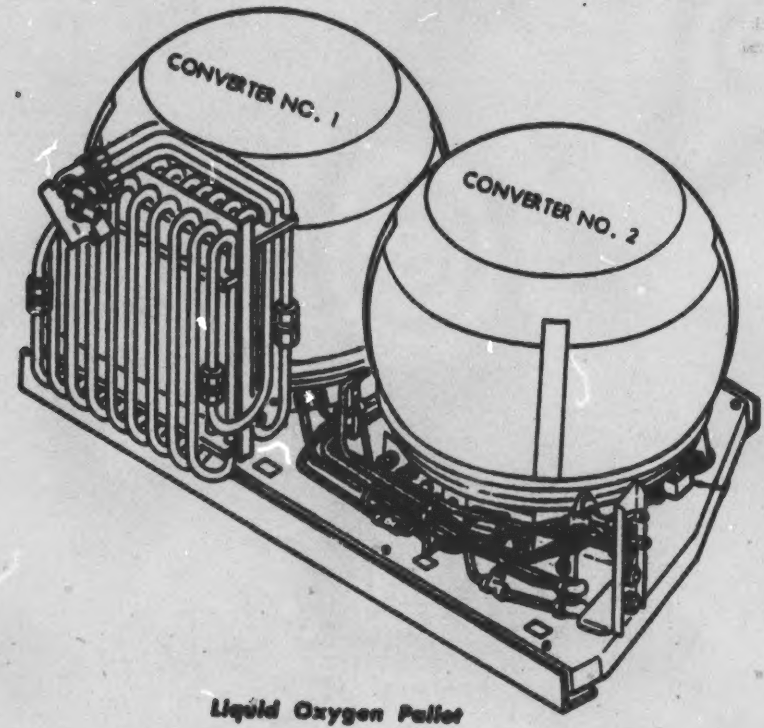
Troop Oxygen System Schematic

//////////////////////

No Response Required

2727

Part of the troop system is the liquid oxygen pallet which is shown on page 5. This pallet will hold two 75-liter converters, two heat exchangers, and the electrical connections and lines that are used to join it to the fixed part of the system. These pallets are completely removable when they are empty, and are repaired by the shop.



Liquid Oxygen Pallet

Check the following statements that are true.

_____1. The liquid oxygen pallet is removable.

_____2. The pallet contains two 75-liter converters.

_____3. The liquid oxygen pallet is repaired by the crew chief.

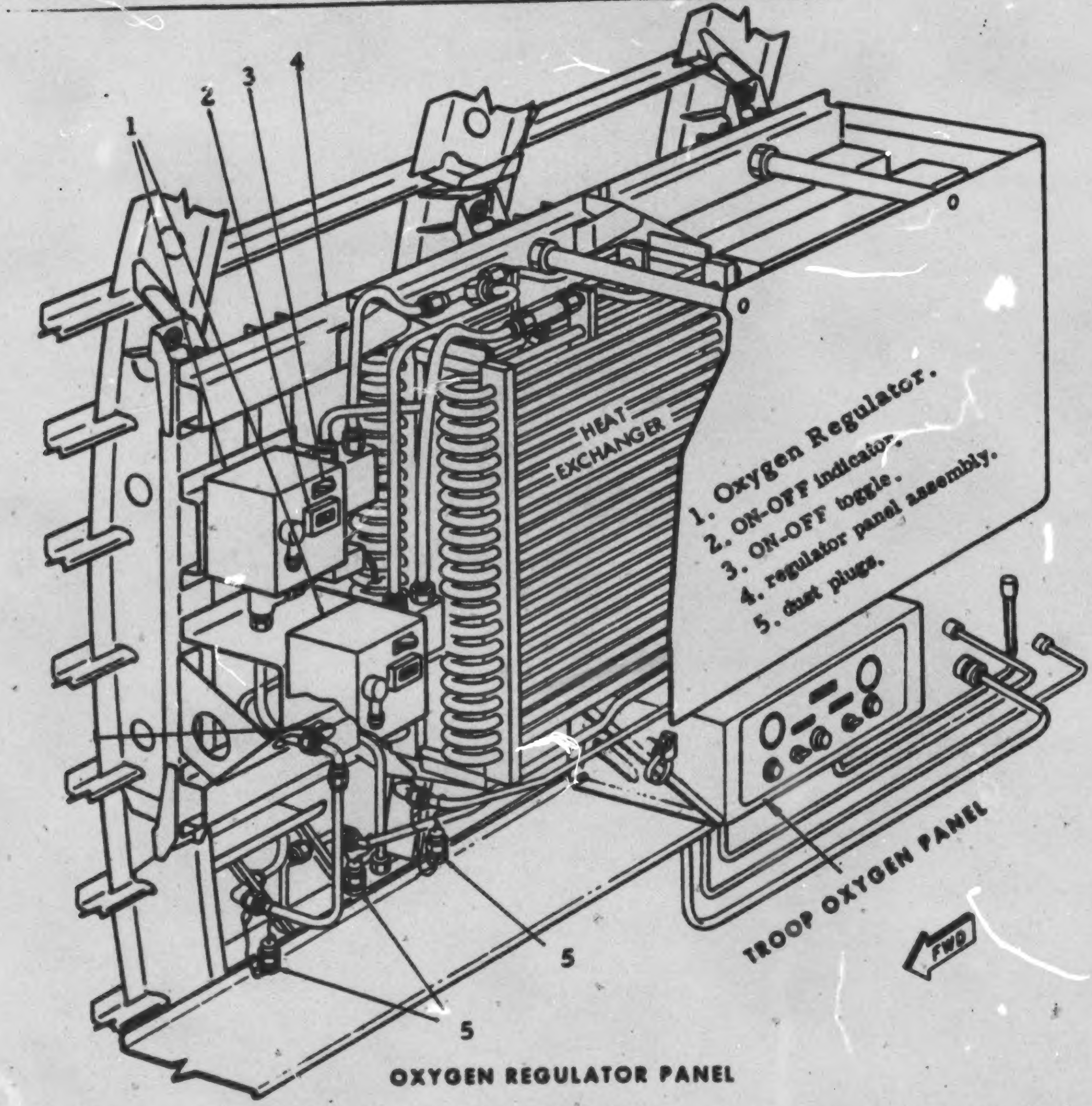
_____4. Heat exchangers are not used on the liquid oxygen pallets.

_____5. The liquid oxygen pallet is part of the troop system.

Answers to Frame 3: ✓ 1. ✓ 2. ___3. ___4. ✓ 5.

Frame 4

The troop regulator panel is in the cargo compartment and is made up of the following items: Two (2) constant flow regulators, four (4) heat exchangers, three (3) dual check valves, and a pressure switch. There is a self contained troop oxygen panel which we will talk about at a later time. The supply lines that are on the panel are joined to each of the regulators through the dual check valves. Because of the different spring loads in the check valves, either or both converters will be able to supply oxygen to either or both regulators. The heat exchangers are used to warm up the gaseous oxygen to a temperature that will be safe for breathing.


1
2
3
4
HEAT EXCHANGER
1. Oxygen Regulator.
2. ON-OFF indicator.
3. ON-OFF toggle.
4. regulator panel assembly.
5. dust plugs.
TROOP OXYGEN PANEL
FWD
5
5

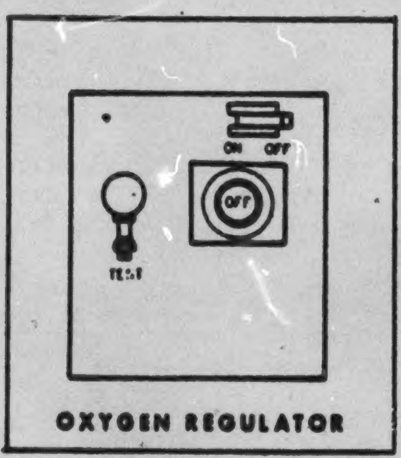
OXYGEN REGULATOR PANEL

//////////////////////

No Response Required

Frame 5

The constant flow regulator that is now being used in the troop system is the Scott 100-man regulator. Two (2) of these regulators are used in this system. They are hooked in parallel so that if one of them fails to work, the supply to the other regulator will not be cut off. The Scott regulator has a built-in flow control valve that will automatically open at a cabin altitude of 12,000 to 14,000 feet to let gaseous oxygen flow to the troop outlets. This flow of oxygen will go on until the cabin altitude drops to 11,000 feet. Look at the sketch shown. A manual on-off switch (top right) is used so that the regulators are able to be turned on at any altitude down to sea level. A pressure operated on-off indicator (center right) is on each regulator to tell you whether or not that regulator is on. The test port is used to check the operation of the indicator.



Check the following statements that are true.

_____1. Scott constant flow regulators have an automatic flow control valve.

_____2. Only one (1) regulator is used in the system.

_____3. The Scott regulator can be manually turned on at any altitude.

_____4. The regulator will automatically open at 12,000 to 14,000 feet cabin altitude.

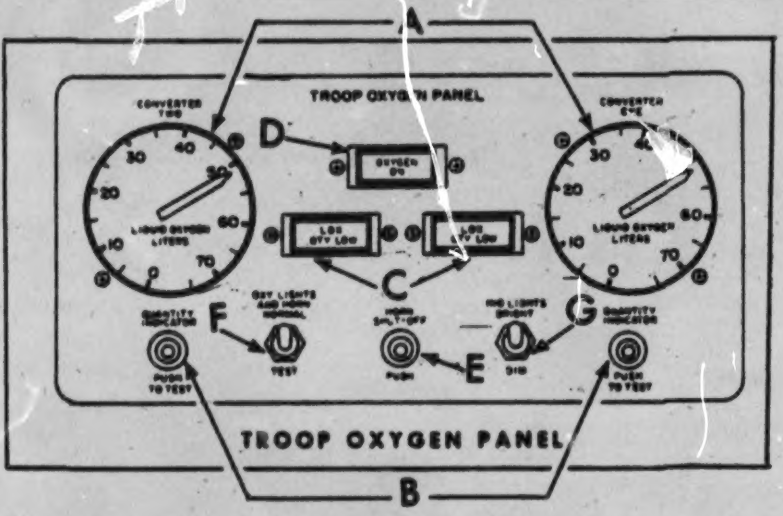
_____5. When the cabin altitude drops to 11,000 feet oxygen will stop flowing.

2730

Answers to Frame 5: ✓ 1. ____2. ✓ 3. ✓ 4. ✓ 5.

Frame 6

The troop oxygen panel (shown below) is joined to the oxygen regulator panel. This panel holds two (2) 75-liter oxygen quantity indicators (A), one for each of the liquid oxygen converters that are found on the pallet. From this part on we are going to refer to liquid oxygen as LOX. There is a "PUSH-TO-TEST" button (B) that is found below each indicator. This button is used to check the operation of that indicator. In each of the quantity indicators there is a microswitch. This switch is used to turn on the LOX quantity low light (C) when the system quantity drops to 7.5 liters. This light tells the crew that they are low on oxygen. There is also a pressure switch found in the system. This switch turns the "Oxygen On" light (D) on when the system is filled with gaseous oxygen. When the oxygen regulators are open and a supply of oxygen is placed in the system, pressure builds up on the emergency horn aneroid which, in turn, sets off the emergency horn that is in the cargo part of the aircraft. This warning horn is also turned on whenever the quantity of the LOX drops below 7.5 liters. There is also a "Horn Shut-Off" button (E) that is located on the oxygen panel. This button is used to manually shut off the horn. The "Oxygen Lights and Horn" test switch (F) is used to check the operation of the horn and oxygen lights. The "Bright and Dim" toggle switch (G) on the oxygen panel is used to manually dim or brighten the oxygen lights.


A
TROOP OXYGEN PANEL
CONVERTER TWO
CONVERTER ONE
D
OXYGEN ON
LOX QTY LOW
LOX QTY LOW
LIQUID OXYGEN LITERS
LIQUID OXYGEN LITERS
0
10
20
30
40
50
60
70
C
QUANTITY INDICATOR
F
OXY LIGHTS AND HORN NORMAL
TEST
HORN SHUT-OFF
PUSH
E
IND LIGHTS BRIGHT
DIM
G
QUANTITY INDICATOR
PUSH TO TEST
PUSH TO TEST
TROOP OXYGEN PANEL
B

Check the following statements that are true.

____1. The troop oxygen panel is used to monitor the supply system.

____2. When the supply drops below 7.5 liters, the LOX QTY LOW light comes on.

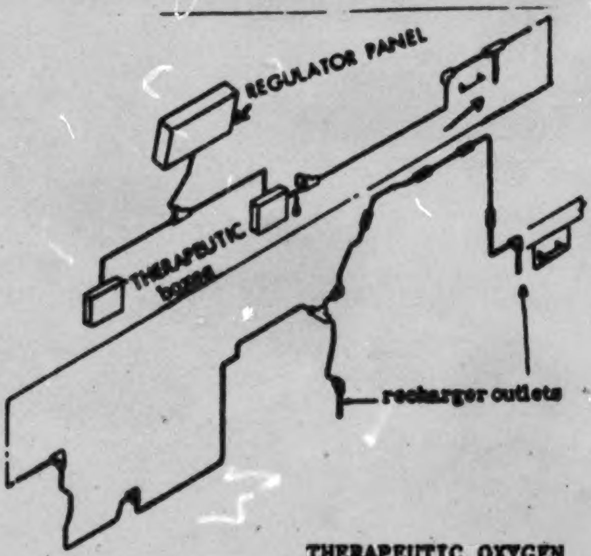
____3. The troop oxygen panel is connected to the oxygen regulator panel.

____4. A warning horn sounds when the converters are empty.

Answers to Frame 6: ✓ 1. ✓ 2. ✓ 3. ____4.

Frame 7

Joined with the troop oxygen system there is a therapeutic oxygen system. This system is to be used for patients that must have special care. It is made up of seven (7) oxygen regulators. These regulators are found in two therapeutic boxes, which are on the right side of the cargo compartment. See the sketch below. These regulators are adjusted by hand to get the right amount of flow. There is a shut-off valve on the oxygen regulator panel. This valve is used to shut off the system when it is not in use. There are three (3) recharger hoses that are used to fill the portable bottles in case more than seven (7) people need therapeutic care.



THERAPEUTIC OXYGEN SYSTEM

Check the following statements that are true.

_____1. The therapeutic oxygen system contains seven (7) hand-adjustable regulators.

_____2. The therapeutic system has seven recharger outlets.

_____3. This system contains a shut-off valve on the oxygen regulator panel.

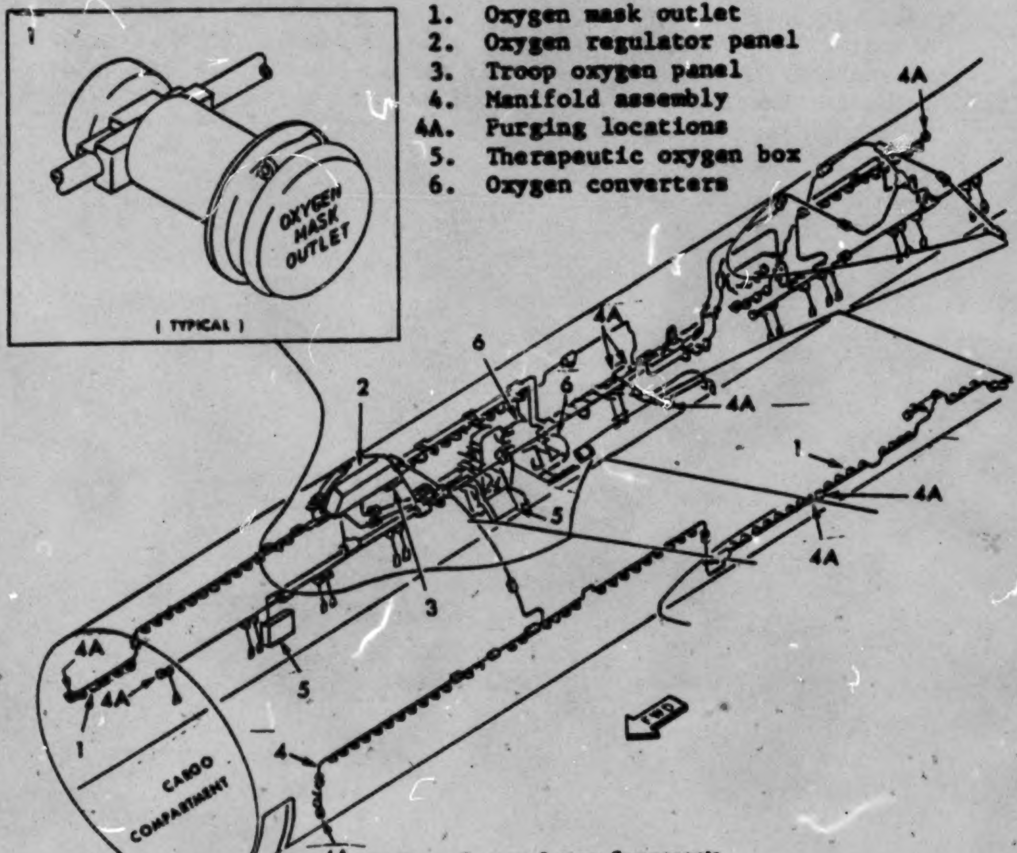
_____4. The seven (7) oxygen regulators are installed in two therapeutic oxygen boxes.

2732

Answers to Frame 7: __✓__ 1. _____ 2. __✓__ 3. __✓__ 4.

Frame 8

The distribution lines are found on each side and on the center top of the cargo compartment. These lines have self-sealing oxygen mask outlets. These outlets have valves which will determine the amount of oxygen that will flow to the mask.


1. Oxygen mask outlet
2. Oxygen regulator panel
3. Troop oxygen panel
4. Manifold assembly
4A. Purging locations
5. Therapeutic oxygen box
6. Oxygen converters
1
OXYGEN MASK OUTLET
(TYPICAL)
4A
6
6
2
4A
1
4A
5
4A
3
4A
4A
1
5
FWD
CARGO COMPARTMENT
4
4A

Troop Oxygen System Components

Check the following statements that are true.

_____1. The oxygen mask outlets are installed in the distribution lines.

_____2. The oxygen mask outlets are self-sealing.

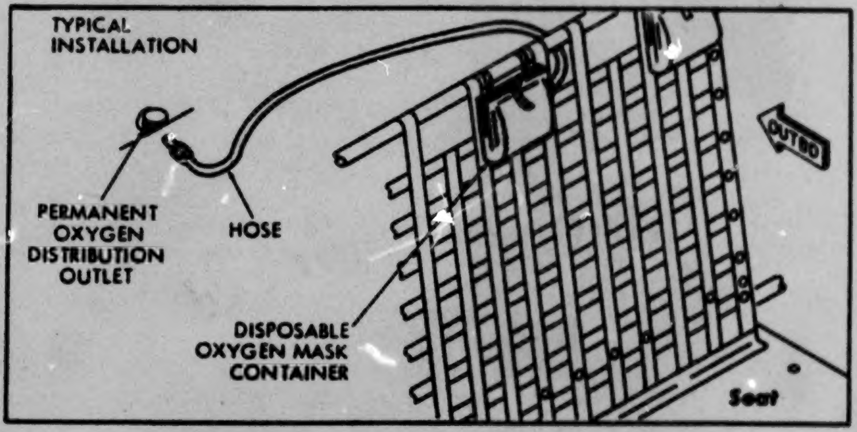
_____3. The oxygen mask outlets are not installed in the cargo compartment.

_____4. The metering valves determine the quantity of oxygen at the mask.

Answers to Frame 8: ___✓___1. ___✓___2. ______3. ___✓___4.

Frame 9

The troop oxygen masks are made of flexible plastic. They are cone-shaped units and have a headstrap. The oxygen is supplied to the mask by a plastic hose which is joined to the oxygen mask outlet. (See the sketch below.) Care should be used to be sure that all of the masks that are plugged in are in use. Since this is a constant flow system, any mask that is plugged in and is not being used will drain the supply of oxygen and could cause a fire hazard by filling the compartment with pure oxygen.


TYPICAL INSTALLATION
PERMANENT OXYGEN DISTRIBUTION OUTLET
HOSE
DISPOSABLE OXYGEN MASK CONTAINER
OUTBD
Seat

Check the following statements that are true.

______1. The troop oxygen masks are cone-shaped.

______2. Oxygen is supplied to the mask by way of aluminum tubing.

______3. The masks are made of plastic.

______4. All masks which are plugged in should be in use.

2734

Answers to Frame 9: ✓ 1. ____ 2. ✓ 3. ✓ 4.

Relate the following six oxygen system components to the statement that best describes their operation in the system. Place its letter in the blank provided.

a. Heat Exchanger

b. On-Off Indicator

c. Microswitch

d. Oxygen Regulators

e. Converter

f. Flow Control Valve

____1. Mounted on each oxygen regulator panel and are used to warm up the gaseous oxygen by absorbing heat from the atmospheric air.

____2. Built into the Scott oxygen regulator and will let gaseous oxygen flow to the troop outlets at a cabin altitude of 12,000 to 14,000 feet.

____3. Mounted inside the quantity indicators on the troop oxygen panel and will turn on the LOX quantity low light when the system quantity drops to 7.5 liters.

____4. Found in the therapeutic oxygen system and are adjusted by hand to get the right amount of oxygen flow to patients who require special care.

____5. Uses the principle of a vacuum bottle to store the liquid oxygen used in the troop system.

____6. Found on the oxygen regulator and is pressure operated to tell you whether or not the regulator is on.

Answers to Frame 10: 1. a 2. f 3. c 4. d 5. e 6. b

IF YOU HAVE MISSED JUST ONE ITEM GO BACK AND REVIEW THIS COMPLETE PROGRAMMED TEXT.

2735

PROGRAMMED TEXT
3ABR42331-PT-402

Technical Training

Aircraft Environmental System Mechanic

CHARACTERISTICS AND SAFE HANDLING OF LIQUID OXYGEN

8 September 1977

3350 TECHNICAL TRAINING WING
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

2736

FOREWORD

This programmed text was prepared for use in the 3ABR42331 Aircraft Environmental Systems Mechanics Course. The materials contained herein were validated using students from the subject course. At least 90% of the students taking this text achieved or surpassed the criteria established in the lesson objectives. The average time for completion of this text was 55 minutes.

OBJECTIVES

After completing this programmed text, you will be able to:

1. Select without error, safety precautions relative to the explosive, fire, and temperature hazards involved in the storage, handling, and use of liquid oxygen.

INSTRUCTIONS

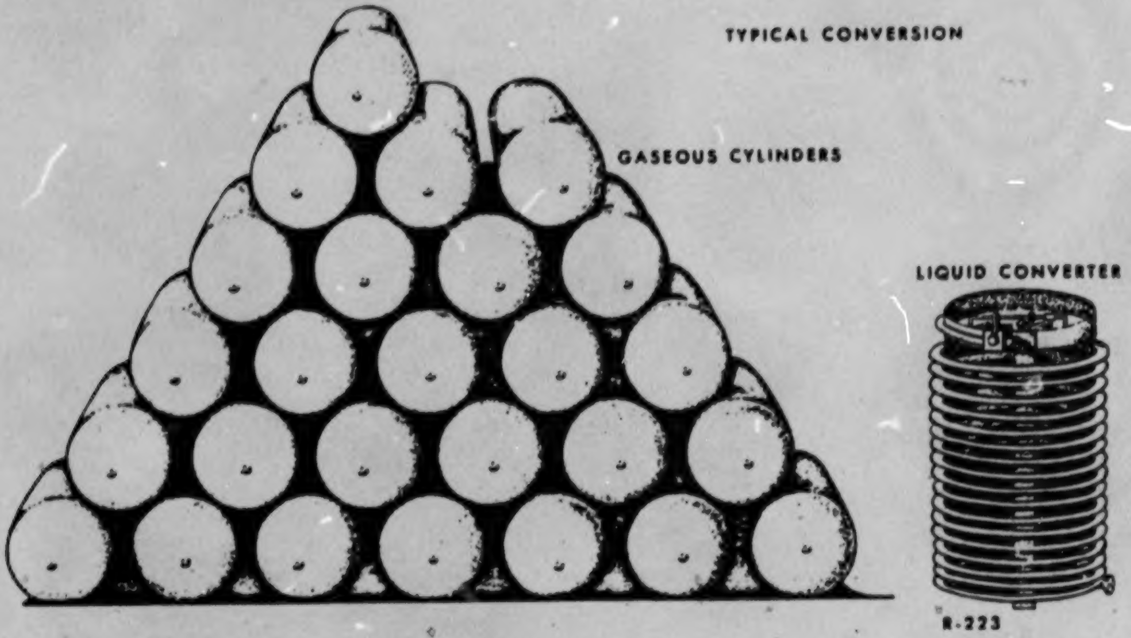
This programmed text presents material in small steps called "frames." After each frame you will find a number of statements and you are asked to select the statement(s) that are true. Read the material in each frame before making a selection. The answers to each frame can be found at the top of the next page. If you select the correct answers, continue to the next frame. If you are wrong or in doubt, read the material again and correct yourself before continuing.

Supersedes 3ABR42331-PT-402, 18 September 1972.
OPR: 3370 TTG
DISTRIBUTION: X
3370 TTGTC - 400; TTVSR - 1

118

Frame 1

While the low pressure and high pressure gaseous systems are still being used on Air Force aircraft, these systems are gradually being changed to the LOX system. Since inflight refueling was introduced, an aircraft can fly for long periods of time. The pilot and crew need large amounts of oxygen. The low pressure gaseous cylinders are light but take up a lot of space. The high pressure cylinders take up less space but are heavier. The best choice was to use the LOX system, which saves space and weight. The average weight and space reduction for all aircraft is 74% (see illustration).



Check the following statement(s) that are true.

_____1. Liquid oxygen saves both space and weight.

_____2. Because of inflight refueling no oxygen is needed.

_____3. High-pressure cylinders will save space but increase weight.

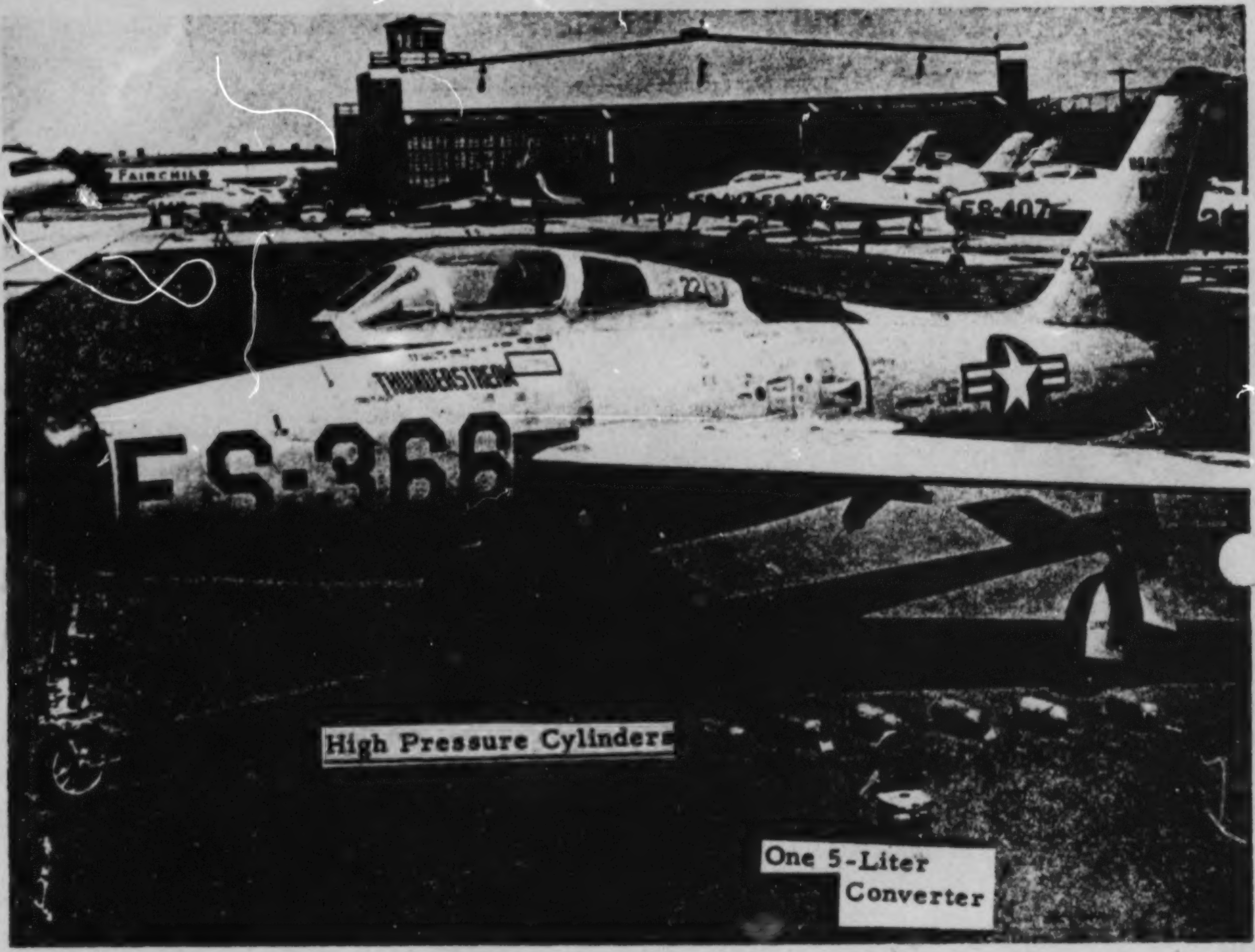
_____4. Average space and weight reduction using liquid oxygen is 74%.

2738

Answers to Frame 1: ✓ 1. ____2. ✓ 3. ✓ 4.

Frame 2

Shown below is an example of space and weight reduction on a fighter aircraft. One five liter LOX converter will replace and give as much oxygen as six high pressure oxygen cylinder.


FAIRCHILD
THUNDERSTREAK
FS-366
FS-407
72

High Pressure Cylinders

One 5-Liter Converter

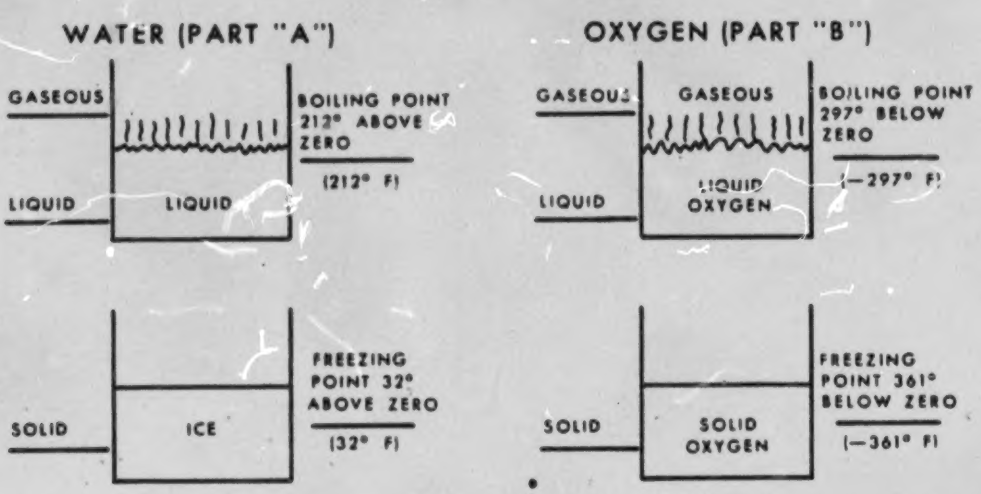
No Response Required

2740

Answers to Frame 3: _✓_ 1. _✓_ 2. _✓_ 3. ____ 4. ____ 5.

Frame 4

As we said earlier, LOX is made by the compression and expansion of air. The temperature of the air when it liquifies is between -297°F and -361°F. When the temperature of the LOX is dropped below -361°F, it becomes a solid, and when the temperature is raised above -297°F the LOX will start to "boil off" and change into a gas (see illustration). The boiling point of LOX is -297°F. The most important thing about LOX is its expansion capability when it changes from a liquid to a gas. One liter (a little more than a quart) of LOX will expand to 860 liters of 70°F gaseous oxygen. You can see the advantages here for aircraft use. The illustration below shows the difference between the boiling and freezing point of water and oxygen.


WATER (PART "A")
GASEOUS
LIQUID
LIQUID
BOILING POINT 212° ABOVE ZERO
(212° F)
SOLID
ICE
FREEZING POINT 32° ABOVE ZERO
(32° F)
OXYGEN (PART "B")
GASEOUS
GASEOUS
LIQUID
LIQUID OXYGEN
BOILING POINT 297° BELOW ZERO
(—297° F)
SOLID
SOLID OXYGEN
FREEZING POINT 361° BELOW ZERO
(—361° F)

Check the following statement(s) that are true.

____ 1. The boiling point of liquid oxygen is -297°F.

____ 2. One liter is slightly more than one quart.

____ 3. Liquid oxygen will not expand very much.

____ 4. At -361°F liquid oxygen will become a solid.

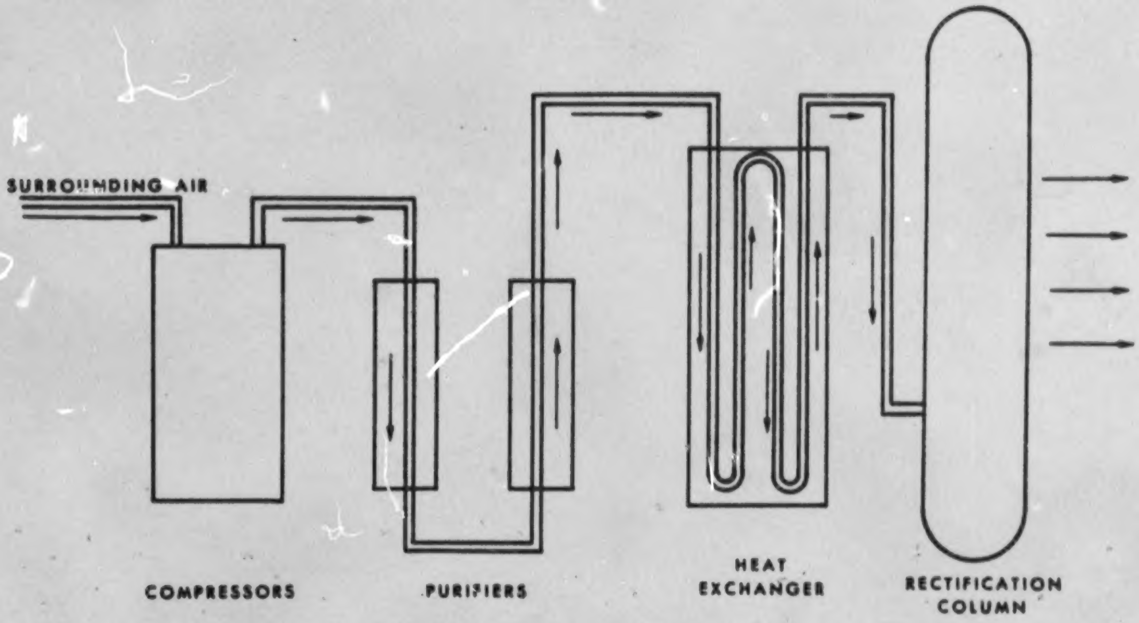
____ 5. The expansion ratio of liquid oxygen is 860 to 1.

____ 6. At a temperature above -297°F the liquid becomes a gas.

____ 7. The most important thing about liquid oxygen is its expansion capability.

Frame 3

From the previous lesson you know that oxygen is a gas that can be changed to a liquid. The first LOX was obtained by Sir James Dewar (a Scottish scientist) in 1886 and was recently adopted for use in aircraft. LOX is made by taking all the carbon dioxide, water, and other impurities from the air. The pure air is then compressed and the heat given off by the compression is taken out through several stages. The highly compressed cold air is then brought through a coil that is submerged in a cooling agent for more cooling. The air is then passed through an expansion valve that will drop the pressure from 3000 psi to 75 psi and the air will turn into a liquid (see illustration below).



Check the following statements that are true.

_____1. Before being liquified the carbon dioxide, water, and other impurities must be removed from the air.

_____2. Oxygen in its normal state is a gas.

_____3. Liquid oxygen is obtained by the compression and expansion of air.

_____4. Liquid oxygen has been used in aircraft since 1886.

_____5. Highly compressed hot air is brought through a coil that is submerged in a cooling agent.

Answers to Frame 4: ✓ 1. ✓ 2. _____3. ✓ 4. ✓ 5.
✓ 6. ✓ 7.

Frame 5

We said gaseous oxygen was colorless, odorless and tasteless. Oxygen in a liquid state has a pale blue color when exposed to the atmosphere. In other words if you drained some out of the storage tank into a bucket it would be a pale blue color. When LOX is exposed to the atmosphere it will evaporate very fast, and if it is spilled on the ground or floor it will form into small "balls" like water on a waxed surface. Be sure not to step on these balls of liquid. If any oil or grease is mixed with the liquid the shock may cause an explosion.

Check the following statements that are true.

_____1. Liquid oxygen is pale blue in color when exposed to the atmosphere.

_____2. At atmospheric temperature liquid oxygen evaporates very rapidly.

_____3. When spilled, liquid oxygen boils off slowly.

_____4. Liquid oxygen forms into small balls like water on a waxed surface.

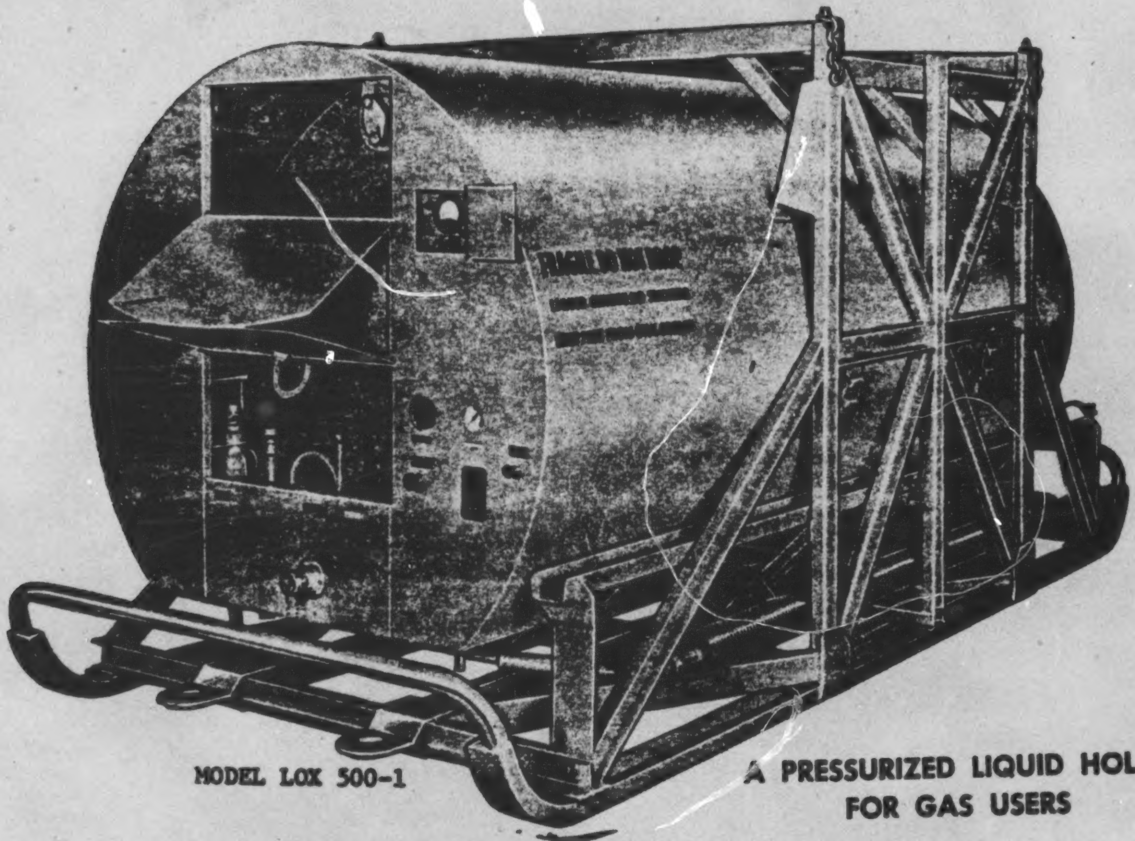
_____5. If you step on spilled liquid oxygen an explosion may occur.

2742

Answers to Frame 5: ✓ 1. ✓ 2. ____3. ✓ 4. ✓ 5.

Frame 6

Oxygen can be kept in a liquid state at atmospheric pressure by keeping its temperature at or below -297°F. There are special containers that have been made to store the LOX (see illustration below). In these containers the oxygen will be able to stay in a liquid state without applying any pressure. By increasing the pressure on the LOX it can be kept at higher temperatures until its critical temperature is reached. The critical temperature of LOX is -182°F and no matter how much more pressure is placed on it, oxygen will not stay in a liquid state above this temperature. The storage containers have vents to the atmosphere because when there is no pressure applied to the LOX, a certain amount of the liquid is going to boil off. To try to hold in the expanding gas is not too practical.



MODEL LOX 500-1

A PRESSURIZED LIQUID HOLDER
FOR GAS USERS

Check the following statements that are true.

____1. By applying pressure to liquid oxygen, it can be kept at a higher temperature.

____2. Pressure will not have any effect on the oxygen boil off.

____3. When liquid oxygen is stored without being under pressure, the containers must be vented.

____4. The critical temperature of liquid oxygen is -182°F.

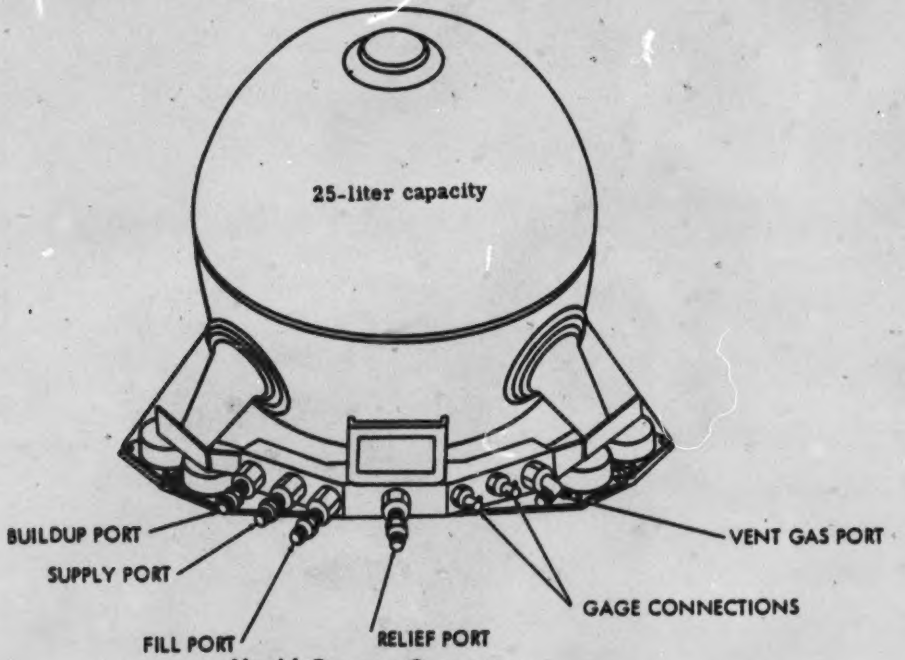
____5. Using special containers, oxygen can be kept in a liquid state without applying pressure.

2743

Answers to Frame 6: ✓ 1. ____ 2. ✓ 3. ✓ 4. ✓ 5.

Frame 7

There are two LOX containers you will be most concerned with. They are the ones used to store LOX on an aircraft and the cart that is used to service the aircraft with LOX. The sketch that is shown below is a typical container that is used on the aircraft. The container by itself is called a LOX converter (sometimes it is referred to as a Dewar Flask), and with the valves and other parts put on it, it is called a converter assembly. The converter is made like a thermos bottle, you could say its a tank within a tank. The liquid is stored in the inner tank and a vacuum between the two walls will prevent a rapid boil off until the liquid has had a chance to cool the metal down to its own temperature. There are various size LOX converters that are available, and they are all measured in liters.



Liquid Oxygen Converter

Check the following statement(s) that are true.

_____ 1. The container used on an aircraft to store liquid oxygen is called a converter.

_____ 2. The converter does not require any insulation from outside heat.

_____ 3. A converter is double walled and vacuum insulated.

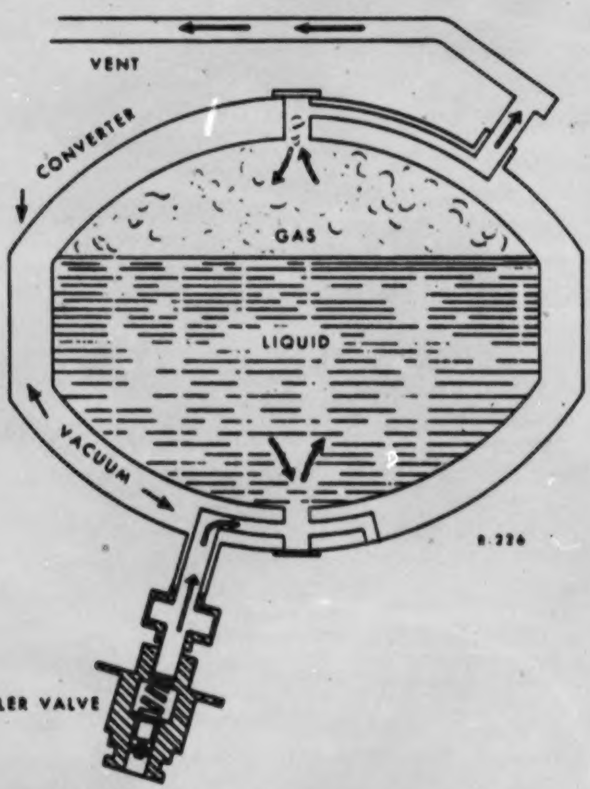
_____ 4. Converter capacity is measured in liters.

2744

Answers to Frame 7: ✓ 1. ____ 2. ✓ 3. ✓ 4.

Frame 8

As we have said before, the LOX converter is a double-walled vacuum insulated container. The capacity of a converter is measured in liters. The size and number of converters that are required on an aircraft is determined by the number of personnel who will need oxygen, and the type of mission that the aircraft is on. LOX converters are made in such a way that they will allow a "head space" for the gas to form once the converter is full of LOX (see the sketch shown). A converter is full when the LOX flows overboard through the vent line. Once the converter is full the gas on top is used to force the LOX out of the bottom where it turns into a gas and flows to the regulators for use.



Check the following statement(s) that are true.

____1. Converters are designed to be filled completely.

____2. The size and number of converters used on a particular aircraft is determined by the number of personnel who require oxygen and the aircraft mission.

____3. A converter is full when liquid oxygen flows overboard.

____4. The gas on top of the converter is used to force the liquid out the bottom.

____5. A head space for gas remains on the top of the converter when it is full.

Answers to Frame 8: ___1. ✓ 2. ✓ 3. ✓ 4. ✓ 5.

Frame 9

Other than the aircraft LOX converter, you will be concerned with the MA-1 LOX storage cart or trailer (see the picture below). This cart, which has four wheels and a 50-gallon LOX storage tank mounted to it, is used to service the aircraft LOX converter. This cart is only one of the units used to service the aircraft with LOX.

Type MA-1 Liquid Oxygen Recharger Trailer

Check the following statement(s) that are true.

___1. The MA-1 storage cart is used to service the aircraft converter.

___2. The MA-1 cart has a capacity of 50 gallons.

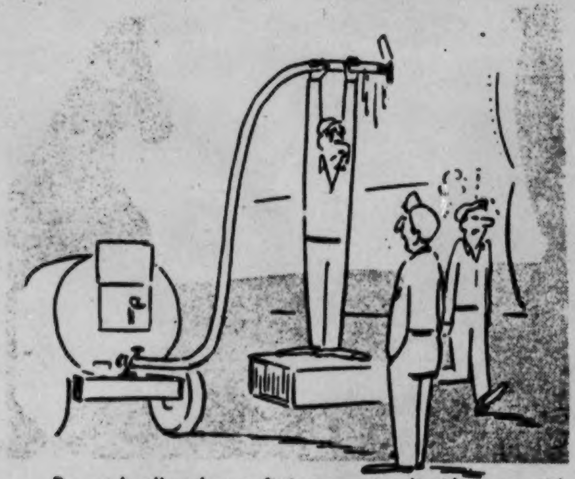
___3. The capacity of the MA-1 servicing cart is measured in liters.

2746

Answers to Frame 9: ___✓___1. ___✓___2. ______3.

Frame 10

The safety precautions you learned and used on gaseous oxygen will also apply to LOX. However, the expansion ratio, which is 860 to 1, and the temperature of the LOX (-297°F) is such that more precautions must be used. Anything that LOX comes in contact with will freeze immediately, this includes your skin. Look at the airman in this sketch that is servicing a LOX converter with the MA-1 servicing cart. He is in for big trouble, because lines and fittings are very cold when LOX is flowing through them. It is very important that you don't touch the servicing hose or the fittings with your bare hands. Protective clothing should be worn at all times while handling LOX.



Do not handle tubes or fittings carrying liquid oxygen with bare hands.

Check the following statement(s) that are true.

_____1. Anything that liquid oxygen touches becomes frozen.

_____2. Liquid oxygen will not harm your skin.

_____3. Protective gloves should be worn when handling tubing that has liquid oxygen flowing through it.

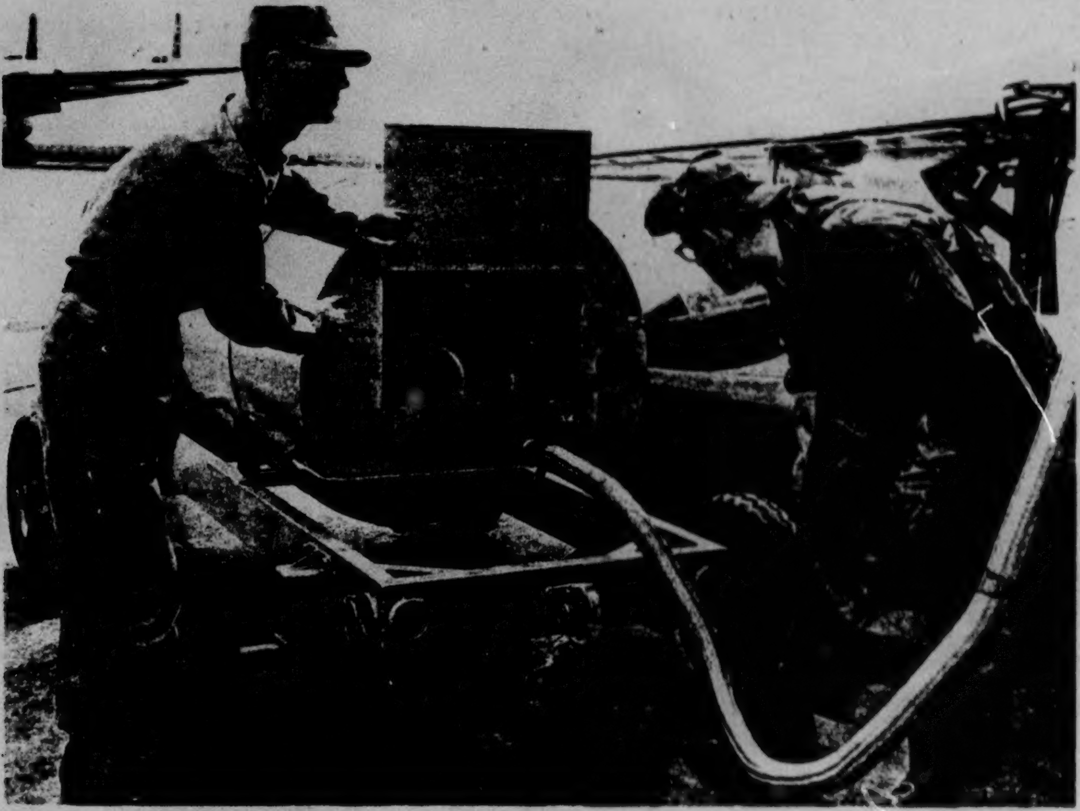
_____4. Because liquid oxygen is extremely cold more safety precautions are required than with gaseous oxygen.

2747

Answers to Frame 10: ✓ 1. ____ 2. ✓ 3. ✓ 4.

Frame 11

The airman in this picture is wearing the right protective clothing. The protective clothing that you will need are a plastic face shield, neoprene (rubber) apron, and a pair of nonabsorbant gloves. These items should be worn anytime you use LOX or there is a chance that you might have some LOX spilled on you.



Check the following statement(s) that are true.

____1. Gloves, apron, and face shield should be worn when transferring liquid oxygen.

____2. Oxygen converters normally should be empty when removed.

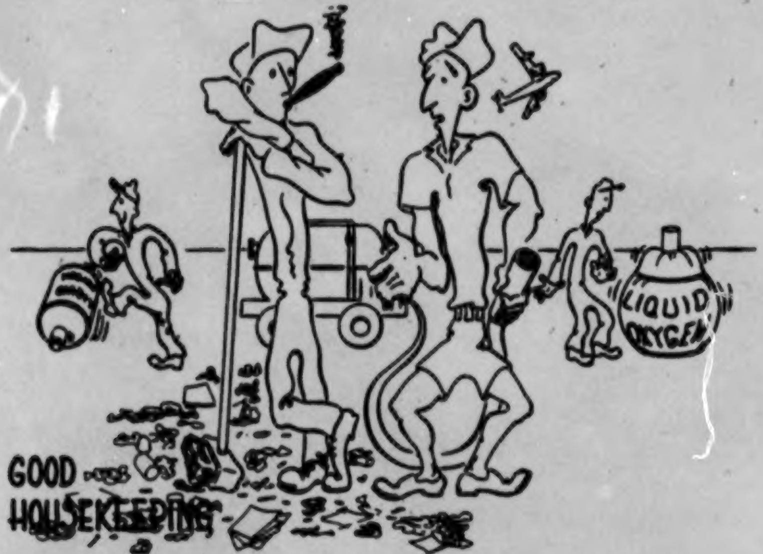
____3. No special clothing is required when handling liquid oxygen.

2748

Answers to Frame 11: __✓__ 1. __✓__ 2. _____ 3.

Frame 12

Because of the characteristics of LOX, it should not be confined. A small amount of LOX will boil off all the time and form a gas. If the gas is confined, a pressure will build up and cause an explosion. If you should spill some LOX on your skin, a severe burn or frostbite will occur. If this happens wash the skin with water and see a doctor as soon as possible. The oxygen area should be kept clean at all times and smoking is not allowed in this area at any time. Note the airmen in this sketch are breaking all of these safety rules.



T56-3674 (2) LIQUID OXYGEN HANDLING PRECAUTIONS

Check the following statement(s) that are true.

_____1. Liquid oxygen should not be confined in a container.

_____2. No smoking is allowed in an oxygen area.

_____3. If liquid oxygen spills on your skin, flush with water and see a doctor immediately.

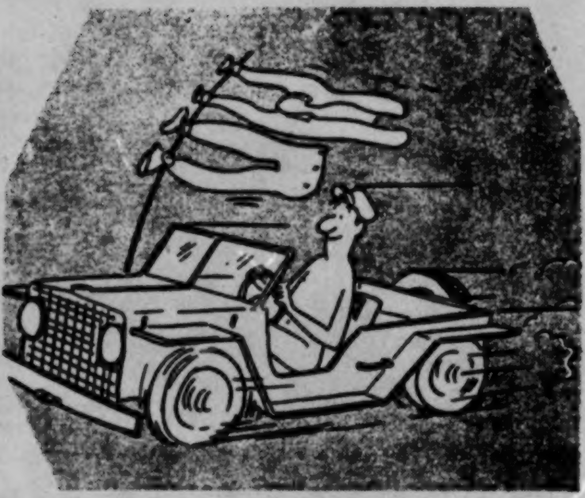
_____4. The oxygen area should be kept clean at all times.

2749

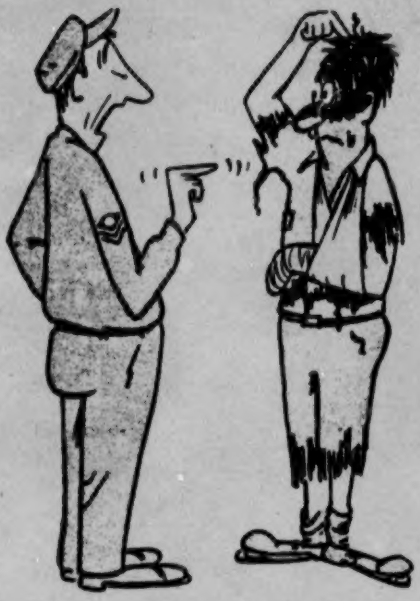
Answers to Frame 12: ✓ 1. ✓ 2. ✓ 3. ✓ 4.

Frame 13

If LOX is spilled on your clothing you should take it off as soon as possible. About 30 minutes should be allowed for the oxygen to evaporate from the material. A serious fire hazard will exist as long as your clothing is saturated with oxygen. All petroleum base products should be kept away from oxygen. An explosion may occur if LOX and items such as oil or grease are mixed and subjected to pressure. It is wise to keep petroleum products at least 50 feet away from oxygen. If LOX is spilled on your skin, it should be washed off with water immediately. This will reduce the chance of frostbite and a possible fire hazard.



If liquid oxygen is spilled on clothing, brush off immediately, remove clothing, and dry for approximately 30 minutes.



Keep all petroleum products (oil, grease, fuel, etc) away from oxygen equipment.

Make sure that body, clothing, and protective equipment are clean and free of petroleum products (hair oil is a petroleum product) before performing maintenance on oxygen system.

Check the following statement(s) that are true.

_____1. Oil and grease should be kept at least 50 feet away from oxygen.

_____2. It takes about 30 minutes for oxygen to evaporate from your clothing.

_____3. Oxygen and petroleum products mixed can cause an explosion.

_____4. Liquid oxygen is removed from the skin with water.

_____5. Frostbite can occur if liquid oxygen is spilled on your skin.

2750

Answers to Frame 13: ✓ 1. ✓ 2. ✓ 3. ✓ 4. ✓ 5.

Frame 14

It is not the desire or intent that these precautions should scare you, but the handling of LOX can be dangerous. We think of an automobile as a useful and pleasurable necessity, but we also know it can be very dangerous when handled improperly. The same is true of LOX. KNOW WHAT YOU ARE DOING AND DO IT RIGHT.

LIQUID OXYGEN MAINTENANCE?

END OF TEXT

2751

PROGRAMMED TEXT 3ABR42331-PT-402A

Technical Training

Aircraft Environmental Systems Mechanic

AIRCRAFT LIQUID OXYGEN SYSTEM BASIC SYSTEM WITH SINGLE FUNCTION VALVES

16 November 1978

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE

DO NOT USE ON THE JOB

2752

FOREWORD

This programmed text was prepared for use in the 3ABR42331 instructional system. The material contained herein has been validated using 38 42010 students enrolled in the 3ABR42331 course. Ninety percent of the students taking this text surpassed the criterion called for in the approved lesson objective. The average student required 43 minutes to complete the text.

OBJECTIVE

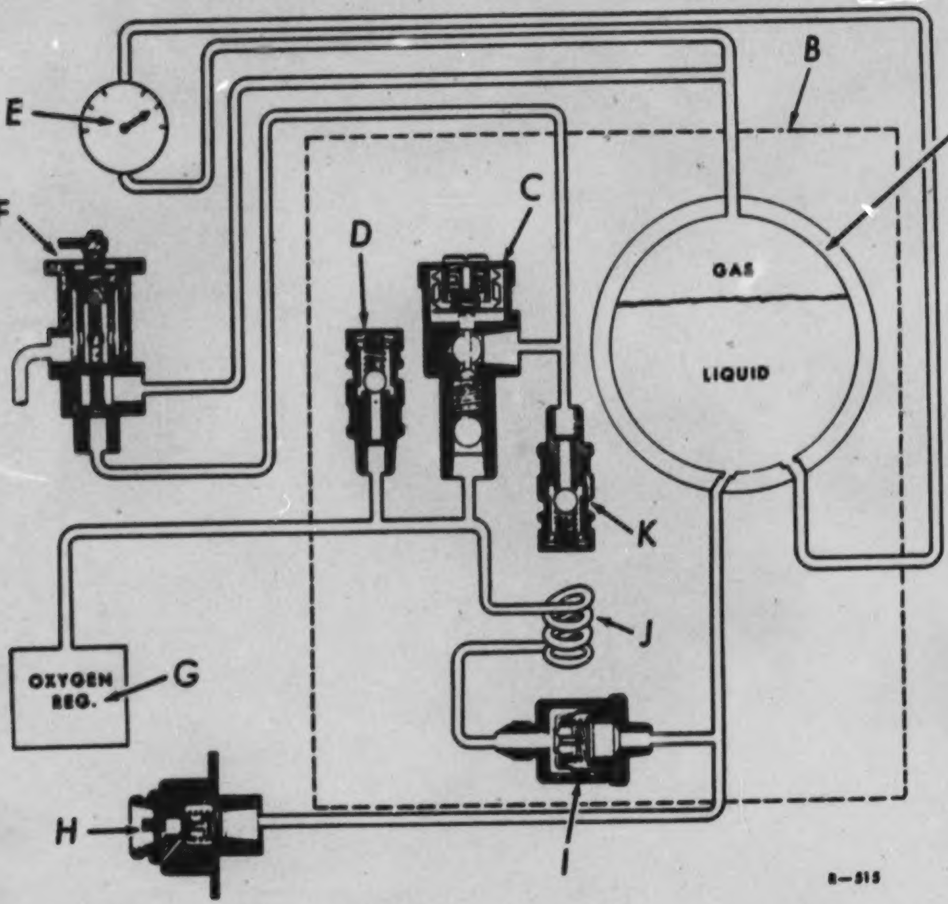
Relate four of five basic liquid oxygen system components to their purpose.

INSTRUCTIONS

As you read and study each frame in this programmed text, locate in the classroom the particular component or system you are reading about. Each individual part and a complete system on a trainer will be available for you to see and inspect. Also, after each frame you will find a number of statements and you are asked to select the true statement or statements from this list. Read the material carefully before making a selection. If you select the correct answers, continue to the next frame. If you are wrong or in doubt, read the material again and correct yourself before continuing. The answers to the statements can be found on the top of the next page.

Supersedes 3ABR42331-PT-314A, 19 February 1970.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 500; TTVSA - 1

Shown below is a basic liquid oxygen system. It consists of a converter assembly (B) which includes everything inside the dashed lines, a filler valve (H), a buildup and vent valve (F), contents gage (E), oxygen regulator (G), and the tubing and fittings required to connect these components together. This basic system has single function valves (valves that have only one purpose). In other systems we have dual function or combination valves that serve more than one purpose. All of these components will be discussed one at a time in this text and will be available in the classroom for you to see and inspect. Review the schematic shown and identify all the components.



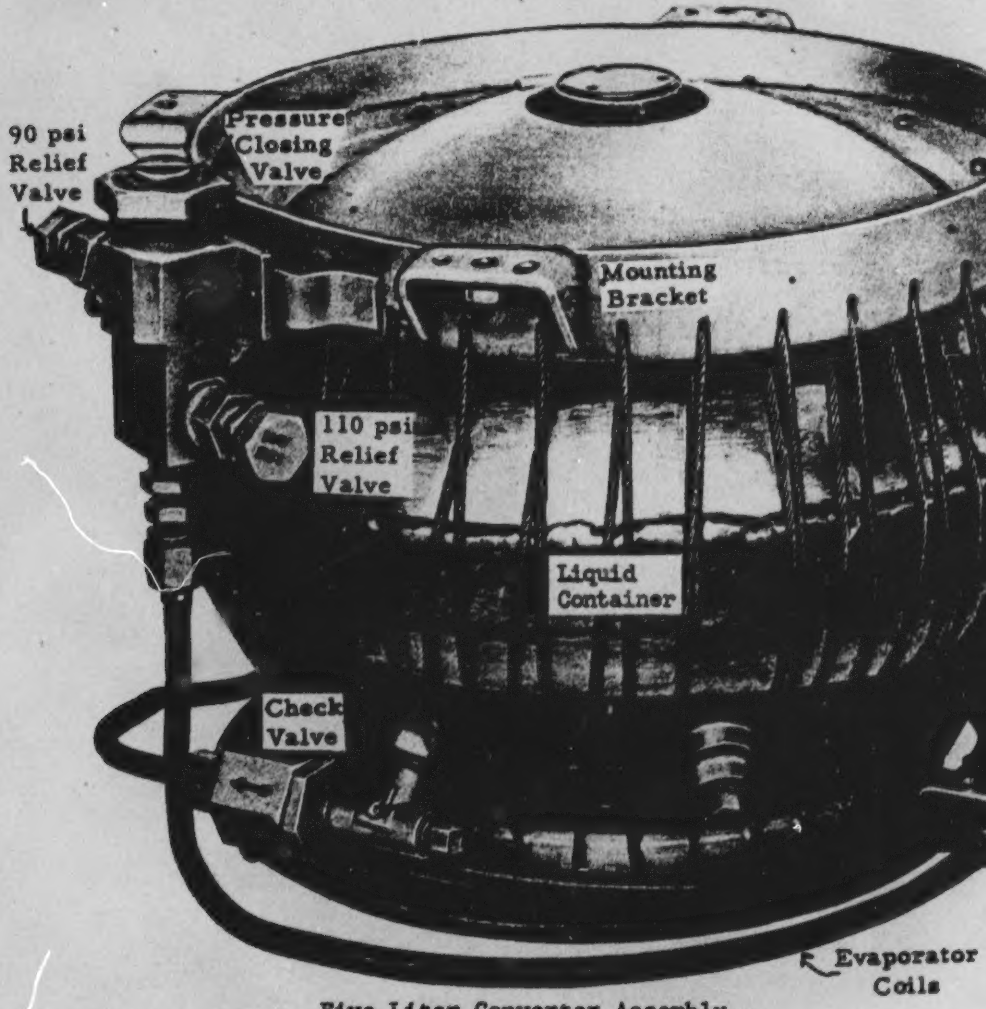
Aircraft Liquid Oxygen System (Single Function Valves).

No Response Required

2754

Frame 2

The liquid oxygen converter assembly is the heart of the liquid oxygen system. This is a multi-function unit that is designed to receive and store the liquid, pressurize the liquid, convert the liquid to a gas (or allows it to be converted), and supply the gas at a constant pressure to the oxygen regulators. Once the liquid container is filled and the system is placed in operation, the conversion from liquid to gas is automatic as long as the gas is being used and as long as the liquid lasts.


90 psi Relief Valve
Pressure Closing Valve
Mounting Bracket
110 psi Relief Valve
Liquid Container
Check Valve
Evaporator Coils

Five Liter Converter Assembly.

Check the following statements that are true.

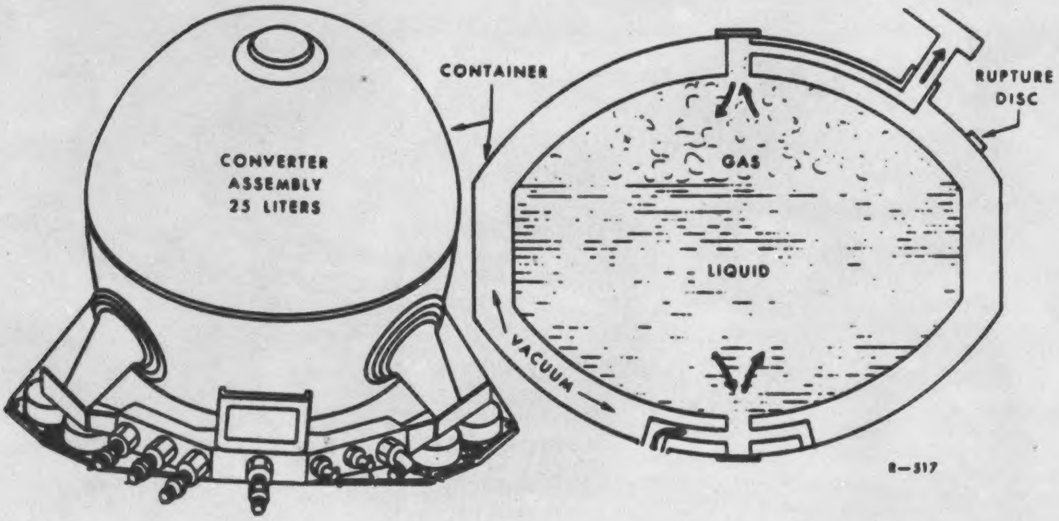
_____1. The converter assembly stores, pressurizes and converts the liquid to gas.
_____2. The converter assembly is the heart of the liquid oxygen system.
_____3. The converter assembly operates automatically once its filled and the system is placed in operation.

2755

Answers to Frame 2. 1. ✓ 2. ✓ 3. ✓

Frame 3

The largest part of the converter assembly is the liquid container. This is a double walled, vacuum insulated unit similar to the common "Thermos" bottle. It is also known as a "Dewar" flask after its inventor. As shown below, the liquid is stored in the inner shell and a vacuum separates it from the outer shell. The outer shell has a rupture disc that will blow out to prevent an explosion if the inner shell develops a leak. The rupture disc will blow at 30 psi. Liquid containers vary in size from 5 to 75 liters capacity.



Check the following statements that are true.

_____1. The container is double walled and vacuum insulated.

_____2. The rupture disc will blow at 30 psi.

_____3. Containers range in size from 5 to 75 liters capacity.

_____4. Liquid oxygen is stored in the vacuum area of the container.

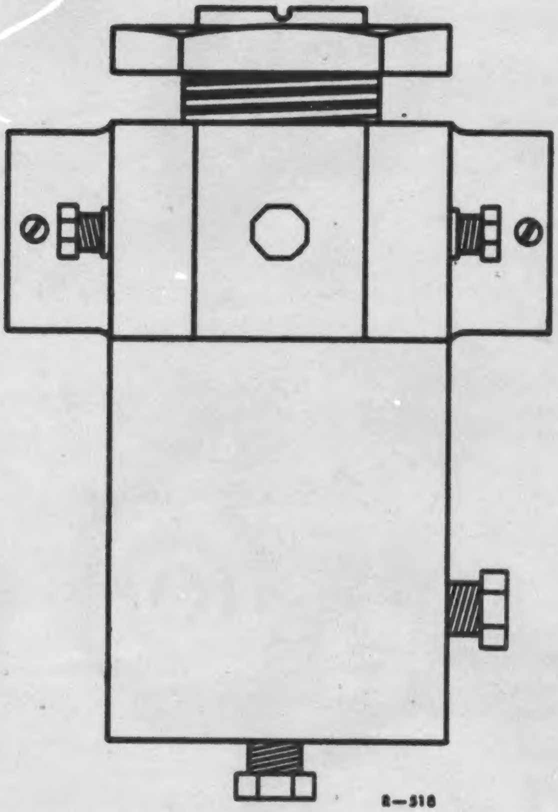
_____5. The largest part of the converter assembly is the liquid container.

2756

Answers to Frame 3. 1. ✓ 2. ✓ 3. ✓ 4. ____ 5. ✓

Frame 4

The pressure closing valve acts as the pressure regulator for the liquid oxygen system. It will either be preset at 70 psi or 300 psi depending upon the type of system the aircraft requires. The main purpose of the high pressure (300 psi) is to allow crew members to fill walk-around bottles from the aircraft system. This means that aircraft like the B-52 and KC-135 would have a high-pressure system.



Pressure Closing Valve

Check the following statements that are true.

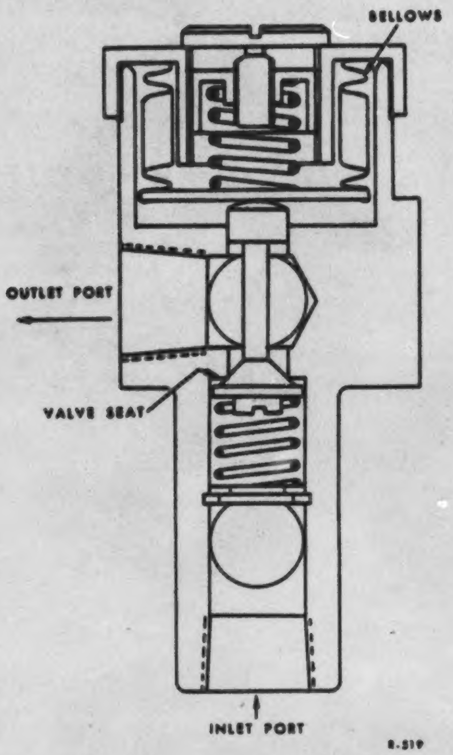
_____1. The pressure closing valve acts as a pressure regulator.
_____2. Fighter aircraft would require a high-pressure liquid oxygen system.
_____3. The pressure closing valve is set at 70 or 300 psi.
_____4. The main reason for having a high-pressure liquid oxygen is to fill walk-around bottles.
_____5. The low-pressure liquid oxygen system operates at 70 psi.

2757

Answers to Frame 4. 1. ✓ 2. ____ 3. ✓ 4. ✓ 5. ✓

Frame 5

Because the pressure closing valve is going to act as the pressure regulator for the system, its primary purpose is to maintain a constant head pressure on top of the liquid in the storage container. The head pressure (gas) is used to push the liquid out the bottom of the container and into the evaporator coil where it is converted to a gas. The bellows in the pressure closing valve (see illustration) will sense the head pressure and open the valve if pressure drops below the valve setting (70 or 300 psi). When the valve opens, gaseous oxygen is transferred from the evaporation side of the system to the build-up side to maintain head pressure. The pressure closing valve is part of the converter assembly.



Check the following statements that are true.

______1. The pressure closing valve maintains a constant head pressure.
______2. The pressure closing valve is part of the converter assembly.
______3. The pressure closing valve acts as the system pressure regulator.
______4. The head pressure (gas) pushes the liquid out of the container.
______5. The pressure closing valve transfers liquid oxygen in the system.

2758

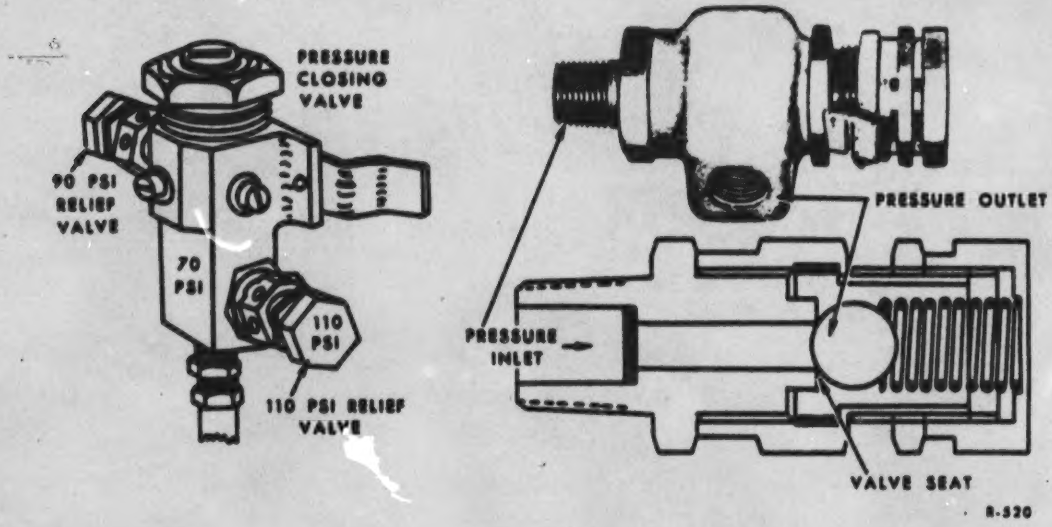
Answers to Frame 5. 1. ✓ 2. ✓ 3. ✓ 4. ✓ 5. ___

Frame 6

In our basic oxygen system we have two (2) relief valves. One valve is in the build-up side of the system and relieves excessive head pressure from the container. This valve is set to open at 90 psi in the 70 psi system and 345 psi in the 300 psi system.

The second relief valve is in the evaporation side of the system (or distribution side) and protects it from excessive pressure. This valve is set to open at 110 psi in a 70 psi system and 395 psi in the 300 psi system.

Both of the relief valves are screwed into the pressure closing valve, one on each side. The relief valves are also part of the converter assembly.


PRESSURE CLOSING VALVE
90 PSI RELIEF VALVE
70 PSI
110 PSI
110 PSI RELIEF VALVE
PRESSURE OUTLET
PRESSURE INLET
VALVE SEAT
R-520

Check the following statements that are true.

_____1. The relief valve in the build-up side relieves excessive head pressure.

_____2. The 110 psi relief valve is in the build-up side.

_____3. The relief valves are screwed into the pressure closing valve.

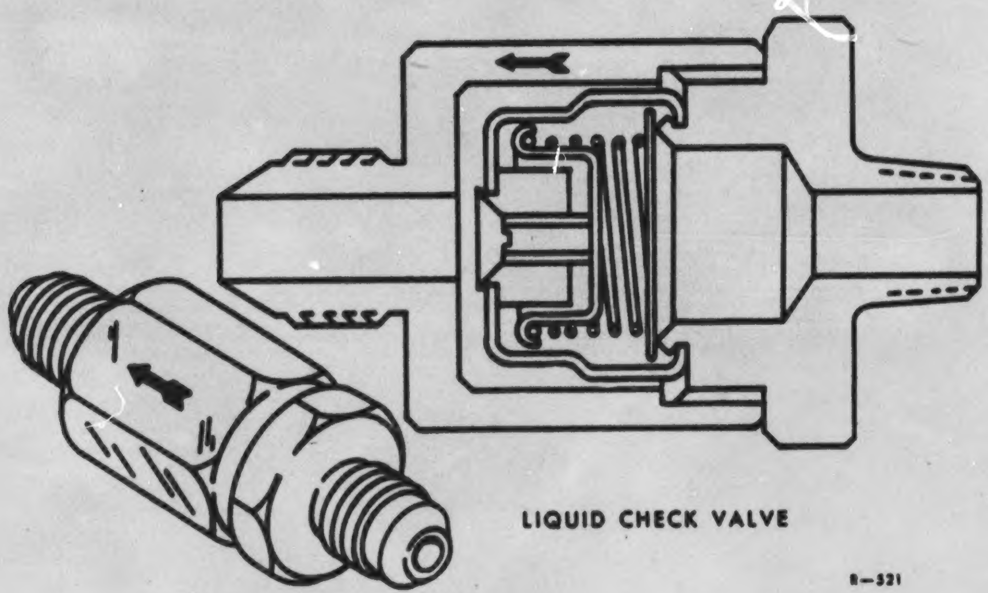
_____4. The evaporation side contains the 110 psi relief valve.

_____5. The 345 and 395 psi relief valves are found in the 300 psi system.

Answers to Frame 6. 1. ✓ 2. ____ 3. ✓ 4. ✓ 5. ✓

Frame 7

The liquid check valve is especially designed to operate in a liquid oxygen system. From its position in the system it will accomplish two things:
1. It separates the liquid phase of operation from the gaseous phase.
2. It prevents a reverse flow of gaseous oxygen (from the gaseous phase) back through the liquid container. During normal operation of the system, the liquid check valve allows liquid to be drawn from the bottom of the container into the evaporation coils in the direction of the arrow. As pressure in the build-up and evaporation sides change because of use or liquid boil-off, the check valve will open and close at 5 psi below the container head pressure. This creates a 5 psi differential between the gaseous phase and liquid phase. When we discuss overall system operation, the function of the valve will become more clear.



LIQUID CHECK VALVE

8-321

Check the following statements that are true.

____1. The check valve separates the liquid and gaseous phase of system operation.

____2. The liquid check valve is especially designed for liquid oxygen systems.

____3. The check valve opens or closes at 5 psi below container head pressure.

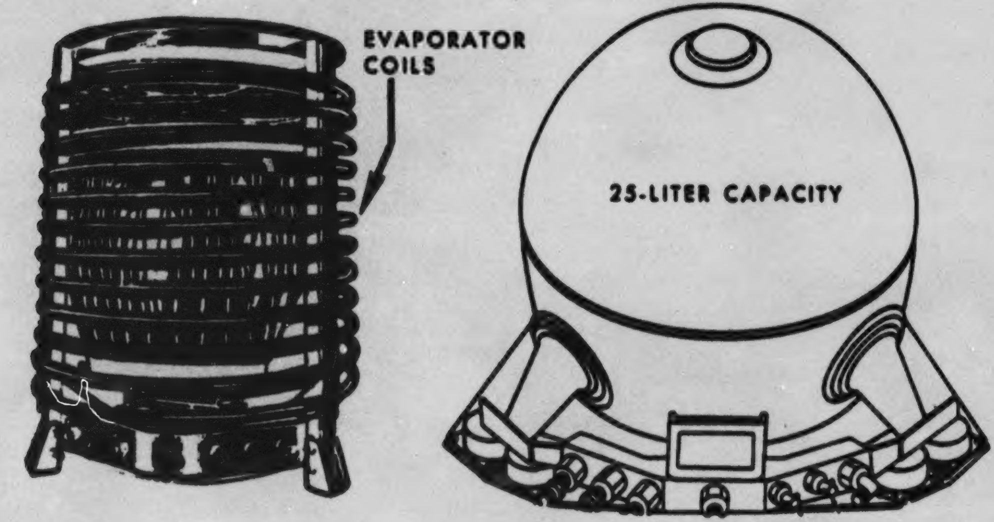
____4. When the check valve closes, it prevents reverse flow.

2760

Answers to Frame 7. 1. ✓ 2. ✓ 3. ✓ 4. ✓

Frame 8

The evaporating coil is made of aluminum alloy and mounted surrounding the liquid oxygen container. This coil presents a large surface area which allows the liquid oxygen to evaporate and turn into a gas. Keep in mind, though, that all converters do not have such a coil. When converters are used in large aircraft where the tubing runs are comparatively long, the evaporator coil is not necessary. The long tubing runs provide the necessary heat-exchanging tubing surface area for evaporation of the liquid oxygen. Note the converter assembly shown on the right below does not have an evaporating coil. In the complete oxygen system, the regulators are connected to the other end of the evaporating coil.



8—533

Check the following statements that are true.

_____1. The liquid changes to a gas in the evaporating coil.

_____2. The evaporation coil can be part of the converter assembly.

_____3. The oxygen regulator is part of the converter assembly.

_____4. The evaporation tubing allows the gaseous oxygen to heat up.

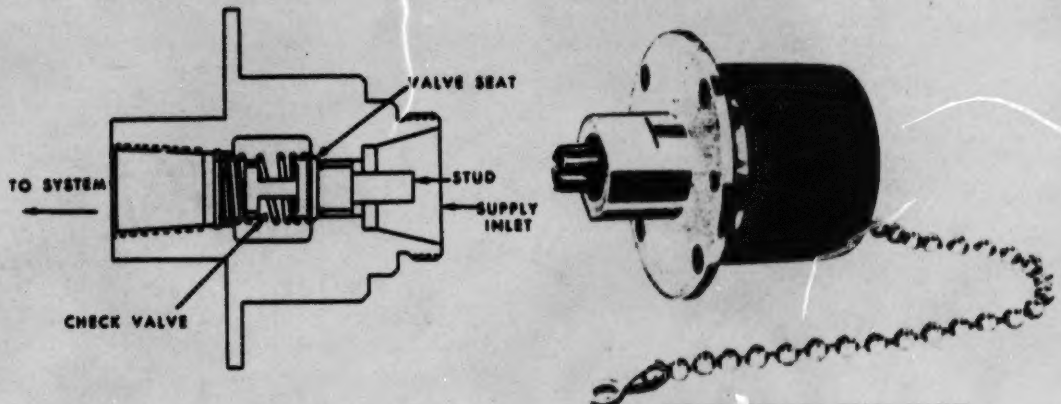
_____5. In large aircraft, an evaporator coil is not always necessary.

2761

Answers to Frame 8. 1. ✓ 2. ✓ 3. ___ 4. ✓ 5. ✓

Frame 9

The filler valve (shown below) is provided for the purpose of filling the system with liquid oxygen. The filler valve is basically a spring loaded check valve assembly with a protective (dust) cap. This valve is also designed for a quick-disconnect coupling with the recharging hose nozzle. When the dust cap is removed from the supply inlet, the supply source (recharging hose) is connected by pushing the nozzle on the valve and making a half-turn. The nozzle on the servicing hose pushes in the stud on the filler valve and unseats the spring loaded check valve and liquid flows in. When the servicing hose is removed, the spring reseats the valve. If an aircraft has more than one converter, each converter will have its own filler valve.



LIQUID OXYGEN FILLER VALVE

8-523

Check the following statements that are true.

_____1. The dust cap prevents the filler valve from leaking.

_____2. One filler valve is needed for each converter.

_____3. The filler valve is basically a spring loaded check valve.

_____4. The filler valve is designed for a quick-disconnect with the servicing hose nozzle.

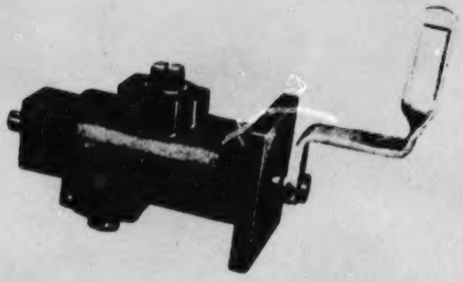
_____5. When filling the system, the servicing hoze nozzle reseats the check valve.

2762

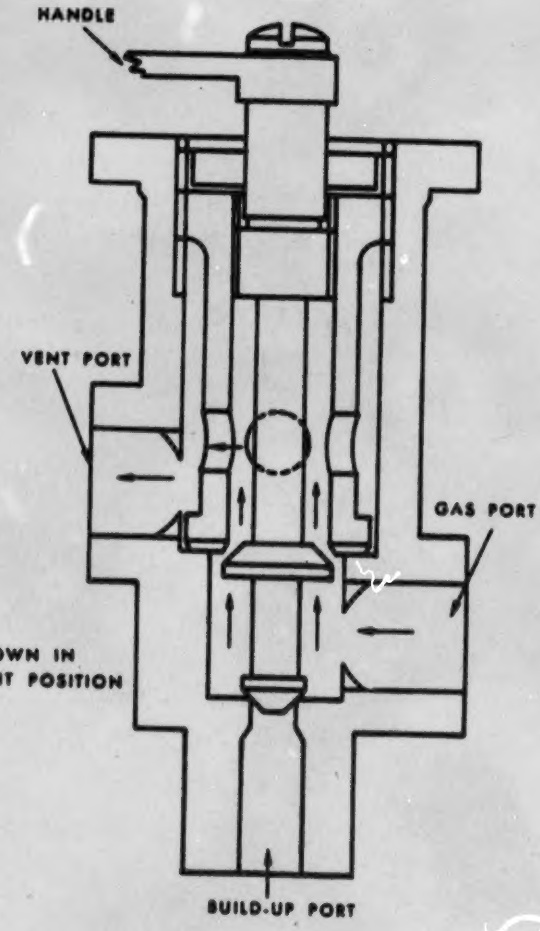
Answers to Frame 9. 1. ___ 2. ✓ 3. ✓ 4. ✓ 5. ✓

Frame 10

The build-up and vent valve (shown below) is a manually operated, two-way rotary valve. When the handle is turned to the "VENT" position, the top of the converter is vented to the atmosphere. In this position, the gas port (from the top of the converter) is now open to the vent port and the build-up port is closed. When the handle is rotated to the "BUILD-UP" position, the gas port is open to the build-up port and the overboard vent port is closed. As with the filler valve, the name of this valve states its purpose; it allows the converter head pressure to "build-up" or be "vented" overboard.



BUILD-UP AND VENT VALVE



Check the following statements that are true.

_____1. The build-up and vent valve is a manually operated valve.

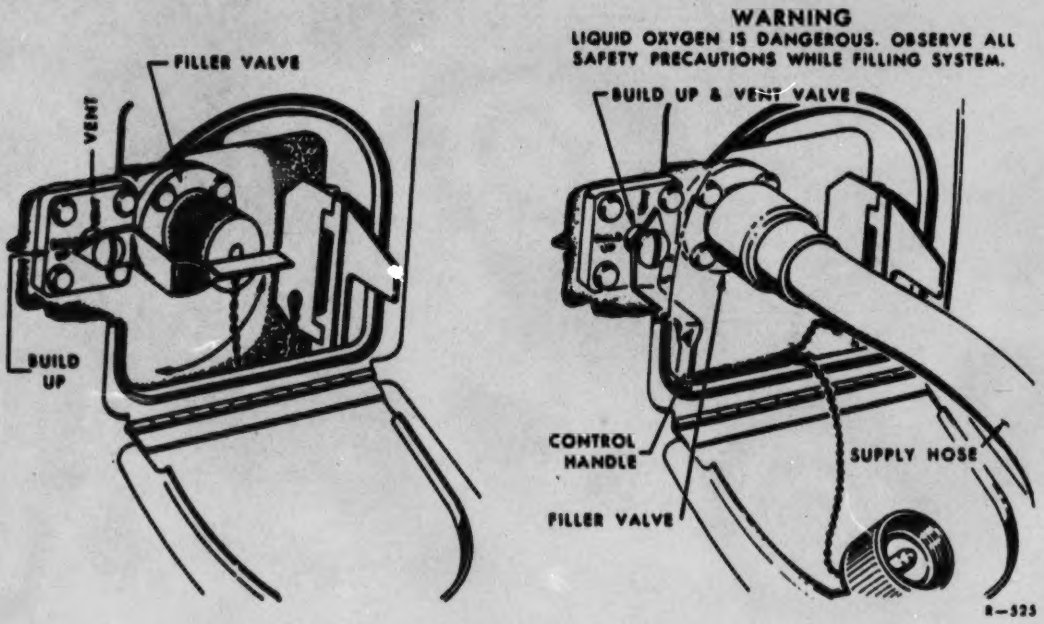
_____2. In "vent," the system will not contain any pressure.

_____3. In "build-up," converter head pressure is trapped and system pressure will rise.

Answers to Frame 10. 1. ✓ 2. ✓ 3. ✓

Frame 11

On the aircraft, the filler valve and build-up and vent valve are located side by side as shown below. When the build-up and vent valve is in "BUILD-UP," the control handle covers the filler valve dust cap and it cannot be removed. This insures that the servicing hose will not be connected with pressure in the system. When servicing the converter, the valve must be in "VENT" as shown on the right. On the other hand, the valve must be in "BUILD-UP" for the pilot to receive oxygen. To insure the valve is in build-up before the aircraft takes-off, the access door (filler well door) is designed so it cannot be closed when the valve handle is in "VENT."


WARNING
LIQUID OXYGEN IS DANGEROUS. OBSERVE ALL SAFETY PRECAUTIONS WHILE FILLING SYSTEM.
FILLER VALVE
VENT
BUILD UP
BUILD UP & VENT VALVE
CONTROL HANDLE
SUPPLY HOSE
FILLER VALVE
R-525

Check the following statements that are true.

_____1. In order to connect the servicing hose, the valve must be in "VENT."

_____2. When the aircraft is flying, the valve must be in "VENT."

_____3. When the valve is in build-up, the filler valve dust cap cannot be removed.

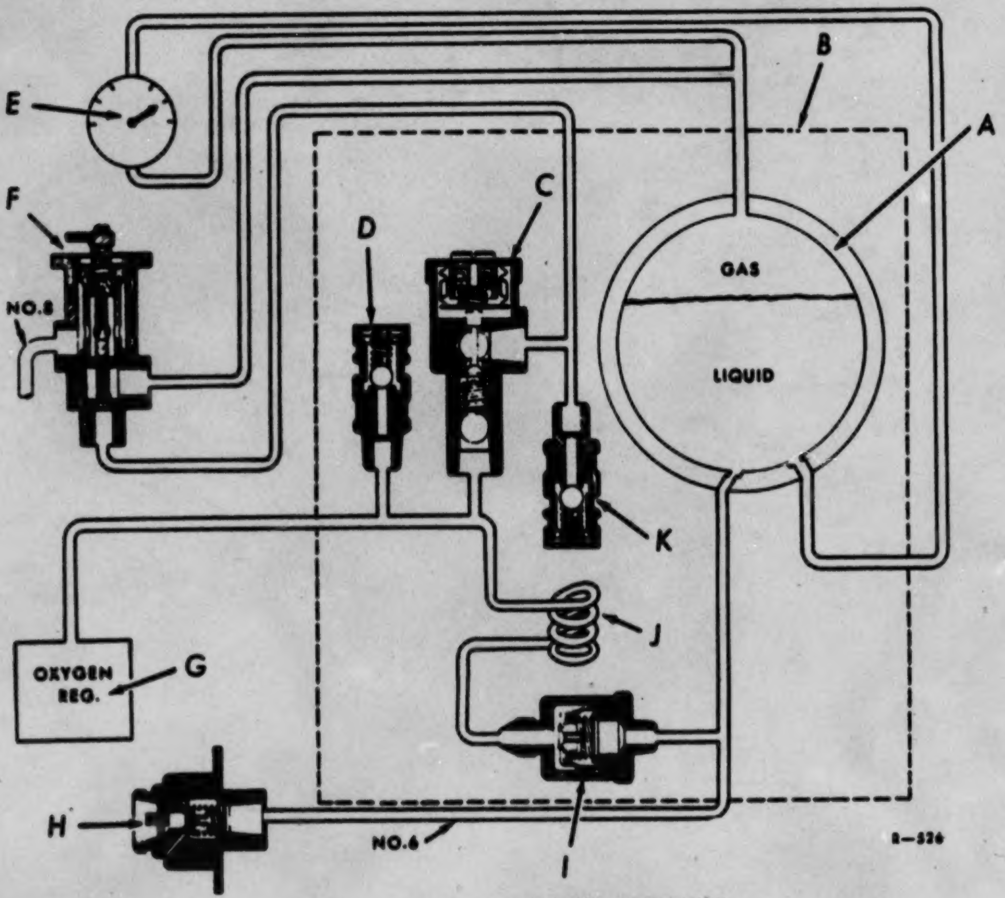
_____4. With the valve in the "vent" position, the access door cannot be closed.

2764

Answers to Frame 11. 1. ✓ 2. ____ 3. ✓ 4. ✓

Frame 12

The tubing (plumbing) used in the liquid oxygen system is aluminum alloy. Also, all of this aluminum tubing will be No. 5 (5/16) except in the following places: 1. The line from the filler valve (H) to the liquid container (A) is No. 6 (3/8). This is the filler line (see below). 2. The line from the build-up and vent valve (F) to the overboard drain is No. 8 (1/2). This is the vent drain line. 3. The size and length of the evaporating coil tubing (J) depends upon the size and type of converter assembly (B) that is being used.



A. CONTAINER
B. CONVERTER ASSEMBLY
C. PRESSURE-CLOSING VALVE
D. 110-PSI OR 395-PSI RELIEF VALVE
E. CONTENTS GAGE
F. BUILDUP AND VENT VALVE
G. OXYGEN REGULATOR
H. FILLER VALVE
I. CHECK VALVE
J. EVAPORATING COIL
K. 90-PSI OR 345-PSI RELIEF VALVE

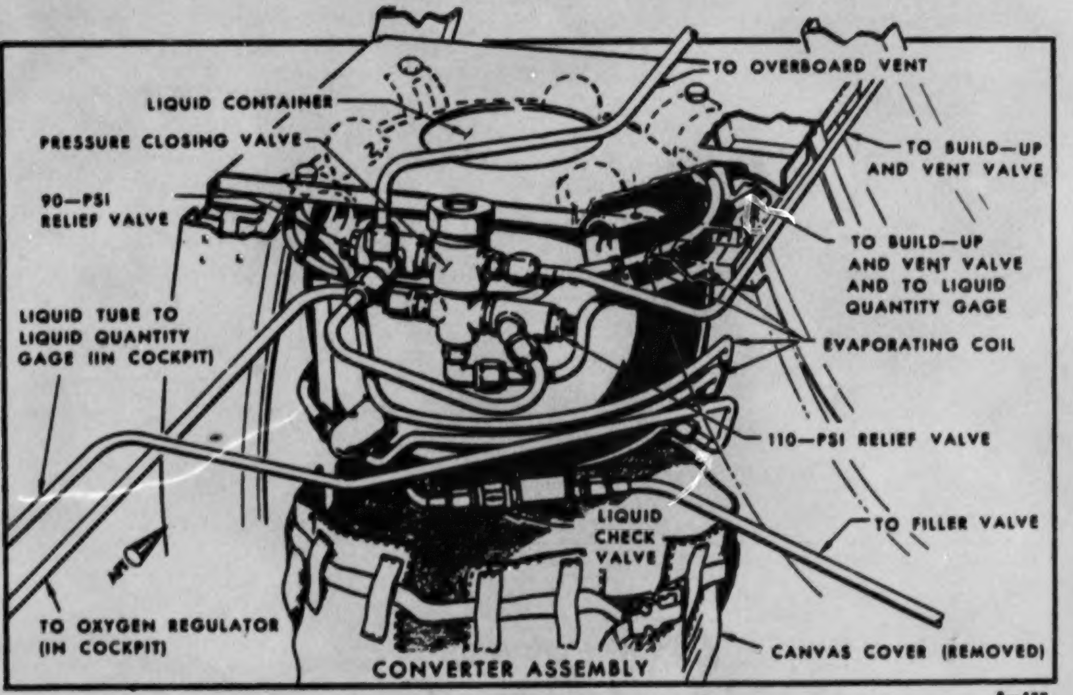
Check the following statements that are true.

_____1. The filler valve is connected to the container with No. 6 tubing.
_____2. Aluminum tubing is used in the liquid oxygen system.
_____3. The vent drain line is No. 8 tubing.
_____4. Most of the liquid oxygen tubing is No. 5.
_____5. The evaporating coil is always No. 5 tubing.

Answers to Frame 12. 1. ✓ 2. ✓ 3. ✓ 4. ✓ 5. ____

Frame 13

Shown below is a typical converter assembly installation. This assembly has the same single function valves we have been discussing. Keep in mind the build-up and vent valve and filler valve are not shown because in this system they are not part of the converter assembly.


TO OVERBOARD VENT
LIQUID CONTAINER
PRESSURE CLOSING VALVE
TO BUILD—UP AND VENT VALVE
90—PSI RELIEF VALVE
TO BUILD—UP AND VENT VALVE AND TO LIQUID QUANTITY GAGE
LIQUID TUBE TO LIQUID QUANTITY GAGE (IN COCKPIT)
EVAPORATING COIL
110—PSI RELIEF VALVE
LIQUID CHECK VALVE
TO FILLER VALVE
TO OXYGEN REGULATOR (IN COCKPIT)
CONVERTER ASSEMBLY
CANVAS COVER (REMOVED)
8—327

Review the illustration above and recall previously taught material to write in the components described in each statement.

1. This valve acts as the system pressure regulator. ________________

2. This valve separates the liquid and gaseous phase of operation. _____

3. The liquid changes to a gas in this tubing. ____________________

4. This relief valve protects the build-up side of the system ______ psi.

5. This unit is vacuum insulated and holds the liquid. ______________

6. The servicing trailer hose is connected to this valve. ____________

7. This valve allows system pressure to build-up or be vented overboard. ____

8. This relief valve protects the evaporation side of the system ____ psi.

9. In the illustration, the pressure closing valve would be set at _____ psi.

2766

Answers to Frame 13.

1. Pressure closing valve.
2. Liquid check valve.
3. Evaporation coil.
4. 90 psi.
5. Liquid container.
6. Filler valve.
7. Build-up & vent valve.
8. 110 psi
9. 70 psi

Frame 14

Refer to the illustration on the next page as you read the material in this frame. In the illustration, we show the flow of liquid and gaseous oxygen with bubbles and slashes in the lines while the system is being filled. Remember the build-up and vent valve has to be in "vent" to remove the filler valve dust cap. Note that with the build-up and vent valve in "vent," the top of the liquid container is vented overboard. Note also the pressure closing valve is "open" and the system contains no pressure. When the system is in "vent," the pressure closing valve is isolated from the top of the container. The pressure loss causes the bellows in the pressure closing valve to expand and open the valve. When the recharging trailer hose is connected to the filler valve, the operator allows 20 to 30 psi head pressure to build-up on top of the liquid in the recharging trailer. This pressure forces liquid into the converter container from the bottom. The container is full when a steady flow of liquid comes out the overboard vent.

Check the following statements that are true.

_____1. When the system is in "vent," the top of the container is vented overboard.

_____2. The pressure closing valve will open when pressure drops around the bellows.

_____3. The converter container is full when liquid comes out the overboard vent.

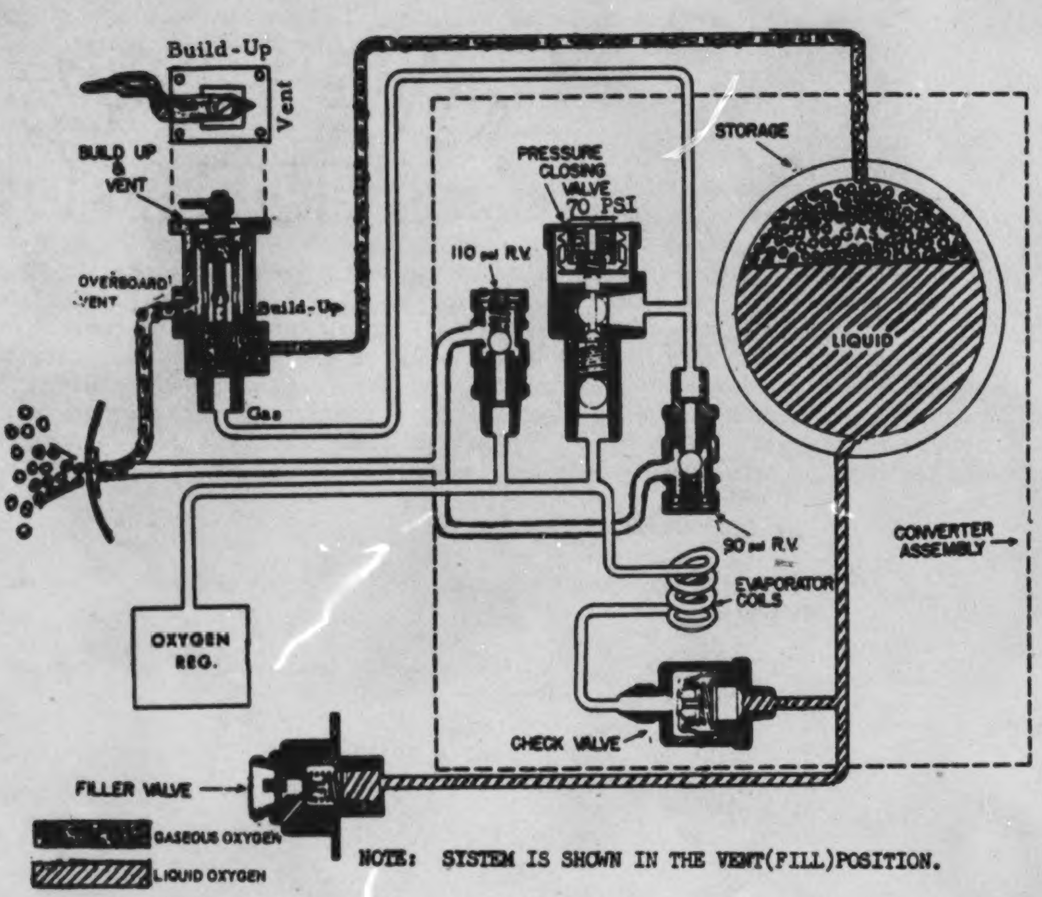
_____4. The system still contains 70 psi when placed in "vent."

_____5. Pressure in the recharging trailer forces liquid into the converter container.

_____6. When placed in "vent," any pressure in the system is vented overboard.

Answers to Frame 14. 1. ✓ 2. ✓ 3. ✓ 4. ___ 5. ✓ 6. ✓

Frame 15


Build-Up
Vent
BUILD UP & VENT
OVERBOARD VENT
Build-Up
Gas
110 psi R.V.
PRESSURE CLOSING VALVE
70 PSI
STORAGE
GAS
LIQUID
90 psi R.V.
CONVERTER ASSEMBLY
EVAPORATOR COILS
OXYGEN REG.
CHECK VALVE
FILLER VALVE
▩ GASEOUS OXYGEN
▨ LIQUID OXYGEN

NOTE: SYSTEM IS SHOWN IN THE VENT(FILL)POSITION.

No Response Required.

2768

Frame 16

Refer to the illustration on the next page when you read the material in this frame. When the liquid container is full, the build-up and vent valve is moved back to the "build-up" position as shown in the illustration. With the system closed, pressure will now start to rise. If you recall, we said previously that the liquid check valve opens to let liquid into the evaporating coil and closes to prevent reverse flow. Also remember the pressure closing valve is open until its bellows senses a 70 psi head pressure (in the low pressure system) on top of the liquid in the container. Note in the illustration that the pressure closing valve is again connected to the top of the container through the build-up and vent valve. Now, when the liquid changes to a gas in the evaporating coil, it goes up through the open pressure closing valve and builds up head pressure on top of the liquid. When 70 psi is reached, the pressure closing valve closes. When this happens, the liquid left in the evaporating coil is still changing to a gas and building pressure in this side of the system. This pressure will soon close the liquid check valve (5 psi differential is required) and the system will stabilize. As gaseous oxygen is used through the regulator, a pressure drop allows the liquid check valve to open and more liquid enters the evaporating coil. As the liquid level decreases in the container, the head pressure decreases also. This will cause the pressure closing valve to open again and allow the evaporation side to build up head pressure. There is little or no lag in maintaining the required head pressure; and for all practical purposes, oxygen is delivered to the regulator at a constant pressure of 70 or 300 psi depending upon the pressure closing valve setting.

Check the following statements that are true.

_____1. The bellows in the pressure closing valve senses the container head pressure.

_____2. In a 70 psi system, the pressure closing valve remains open until 70 psi is reached.

_____3. If excessive pressure builds up in the evaporator coils, the 90 psi R. V. will open.

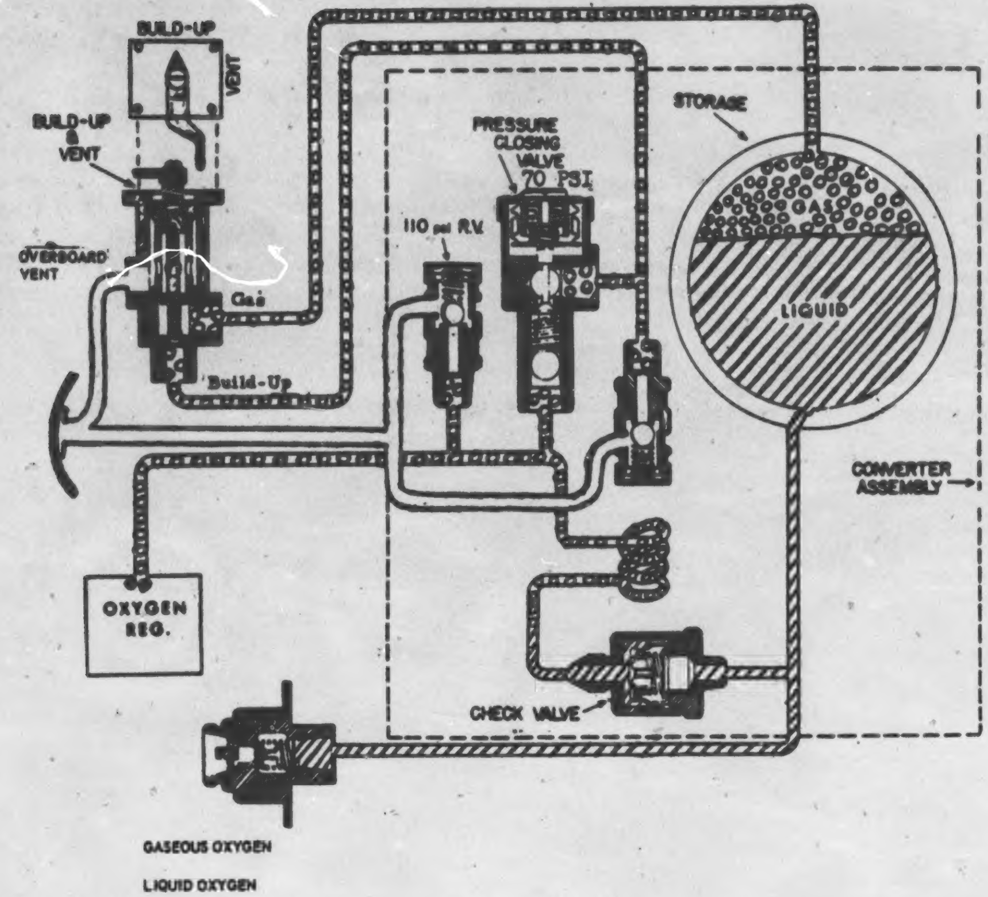
_____4. The liquid check valve prevents reverse flow between the gaseous and liquid phase of the system.

_____5. When pressure in the evaporation side is lower than the head pressure on the container, the liquid check valve will open.

2769

Answers to Frame 16. 1. ✓ 2. ✓ 3. ___ 4. ✓ 5. ✓

Frame 17


BUILD-UP
VENT
BUILD-UP & VENT
OVERBOARD VENT
Gas
Build-Up
110 psi R.V.
PRESSURE CLOSING VALVE
70 PSI
STORAGE
GAS
LIQUID
CONVERTER ASSEMBLY
OXYGEN REG.
CHECK VALVE
GASEOUS OXYGEN
LIQUID OXYGEN

No Response Required

2770

Frame 18

Refer to the illustration on the next page when you read this material. In this illustration we have a separate build-up coil in our basic oxygen system. This is a short coil of tubing that changes the liquid to a gas for the sole purpose of maintaining a head pressure on top of the liquid in the container. Note that this coil of tubing runs directly from the bottom of the container to the bottom of the pressure closing valve. When a separate buildup coil is used, the evaporator coil no longer has to supply gaseous oxygen for a head pressure and more oxygen is available at the oxygen regulator for breathing. This additional circuit in no way affects the operation of the pressure closing valve. The bellows in top of the pressure closing valve still senses the head pressure through the build-up and vent valve. If the head pressure drops below 70 psi (or 300 in the high-pressure system), the pressure closing valve bellows and expands and unseats the valve. The buildup coil will not rebuild the head pressure. The build-up coil is usually around the liquid container and becomes part of the converter assembly.

Check the following statements that are true.

_____1. The build-up coil provides gaseous oxygen for maintaining a head pressure.

_____2. The build-up coil provides gaseous oxygen for the oxygen regulator.

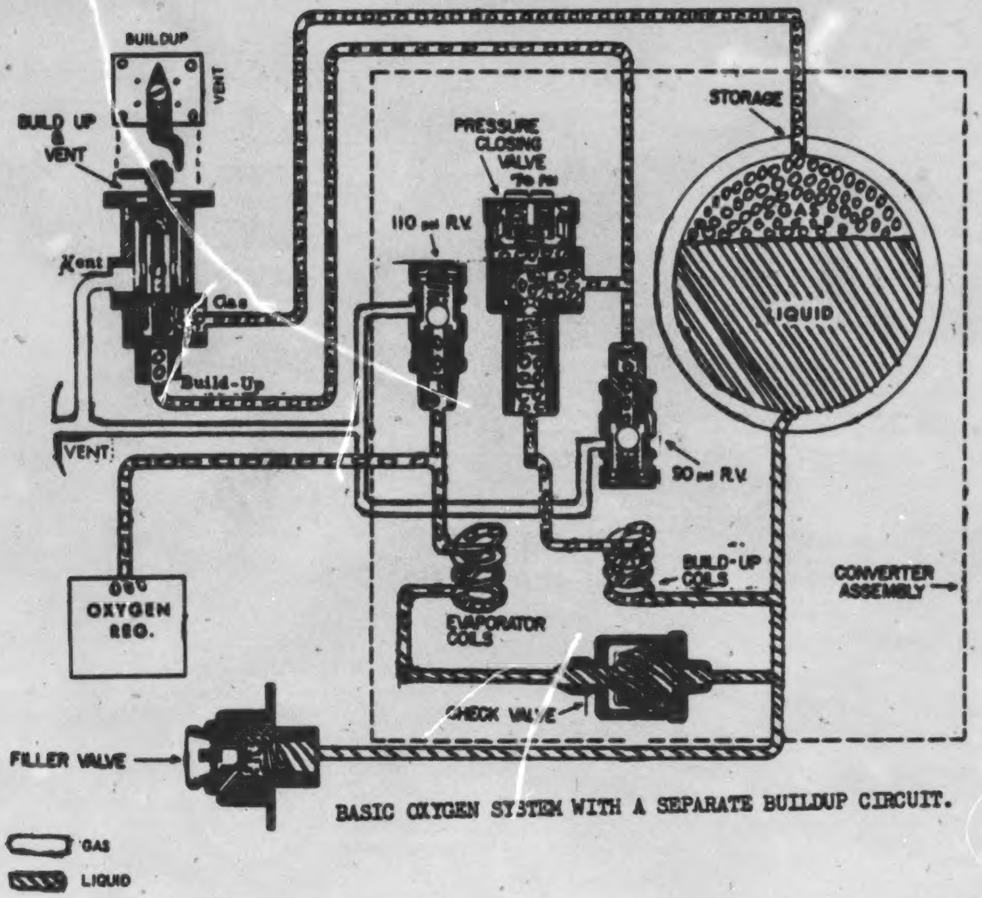
_____3. The build-up coil is part of the converter assembly.

_____4. When a build-up coil is used, the evaporator coils supply gaseous oxygen for breathing purposes only.

_____5. The pressure closing valve operates the same way when a build-up coil is used.

Answers to Frame 18. 1. ✓ 2. ___ 3. ✓ 4. ✓ 5. ✓ 2771

Frame 19


BUILDUP
VENT
BUILD UP & VENT
Vent
Gas
Build-Up
VENT
OXYGEN REG.
STORAGE
PRESSURE CLOSING VALVE 70 psi
110 psi R.V.
GAS
LIQUID
90 psi R.V.
BUILD-UP COILS
CONVERTER ASSEMBLY
EVAPORATOR COILS
CHECK VALVE
FILLER VALVE
GAS
LIQUID

BASIC OXYGEN SYSTEM WITH A SEPARATE BUILDUP CIRCUIT.

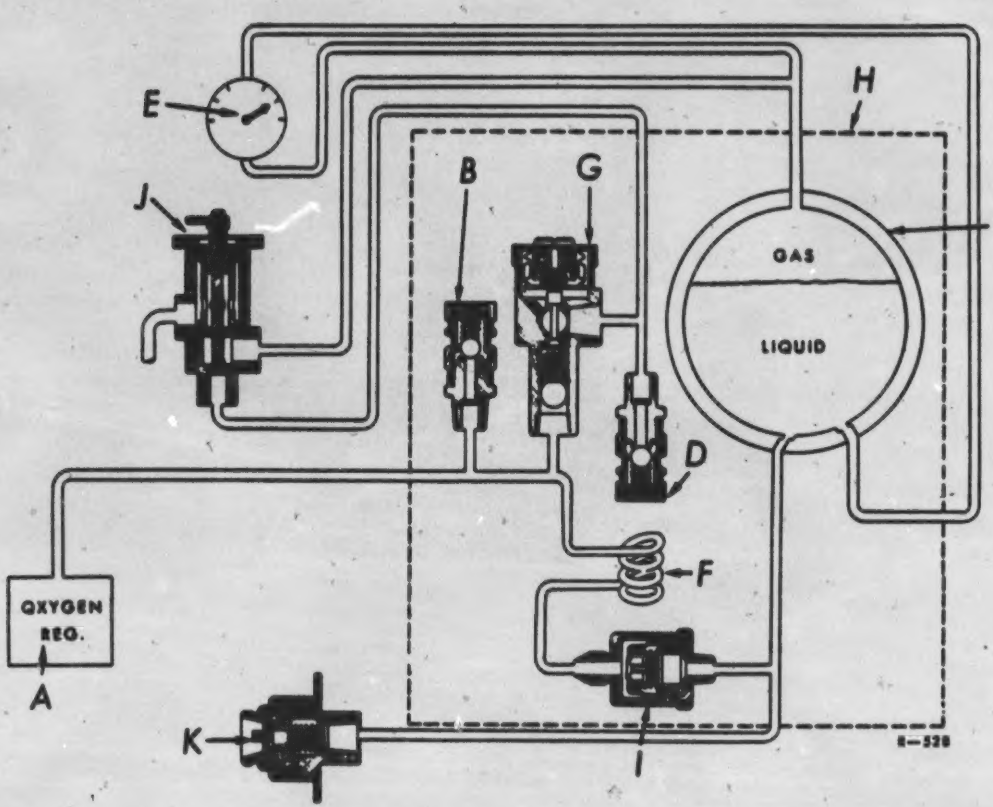
No Response Required

2772

Frame 20

INSTRUCTIONS

Identify the units in the oxygen system by matching the letters with the unit's name below.



1. _____ liquid container.

2. _____ converter assembly.

3. _____ pressure closing valve.

4. _____ 110 or 395 psi relief valve.

5. _____ contents gage.

6. _____ build-up and vent valve.

7. _____ oxygen regulator.

8. _____ oxygen filler valve.

9. _____ liquid check valve.

10. _____ evaporator coils.

11. _____ 90 or 345 psi relief valve.

Answers to Frame 20

1. C
2. H
3. G
4. B
5. E
6. J
7. A
8. K
9. I
10. F
11. D

Frame 21

This completes our discussion on the basic liquid oxygen system. If you have any questions about the operation or components in this system, let your instructor know.

LIQUID OXYGEN

Remember Your Liquid Oxygen Safety.

2774

PROGRAMMED TEXT

3ABR42331-PT-402B

Technical Training

Aircraft Environmental Systems Mechanic

AIRCRAFT LIQUID OXYGEN SYSTEM ADVANCED DESIGN WITH DUAL FUNCTION VALVES

20 November 1978

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.

Do Not Use on the Job.

2775

FOREWORD

This programmed text was prepared for use in the 3ABR42331 instructional system. The material contained herein has been validated using 30 students enrolled in the 3ABR42331 course. Ninety percent of the students taking this text surpassed the criterion called for in the approved lesson objective. The average student required (58) minutes to complete the text.

OBJECTIVES

After completing this programmed text, you will be able to:

1. Relate four (4) of five (5) advance liquid oxygen system components with their purpose.

INSTRUCTIONS

As you read and study each frame in this programmed text, locate the individual component or system being discussed in the classroom or lab. A better understanding of the system will result if you look at and inspect these units as you read about them. Check with your instructor if these components are not available.

After each frame in the programmed text, you will find a number of statements and you are asked to select the true statement or statements from this list. Read the material carefully before making a selection. If you select the correct answer(s) continue to the next frame. If you are wrong or in doubt, read the material again and correct yourself before continuing. Check with your instructor if you have any problems.

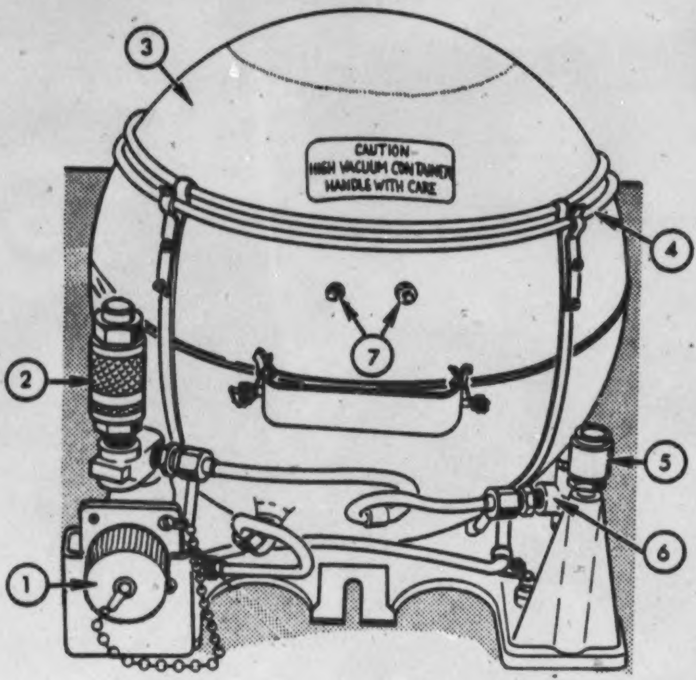
Supersedes 3ABR42231-PT-314B, 18 February 1970.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 600; TTVSA - 1

2776

Frame 1

In this text we will discuss a typical liquid oxygen system that has dual function valves. Shown below is a converter assembly used in the F-4 fighter aircraft. There are several converters that can be used in the F-4 and two of these will be discussed. Since you are already familiar with the components in the basic oxygen system, we will be concerned only with the units that are different in this system and the system operation. We will be concerned mainly with the fill, build-up, and vent valve (1), and the pressure opening-pressure closing valve which is not visible in the illustration below. This converter assembly is equipped with quick disconnects to allow for quick installation and removal. Review the components shown and locate the actual converter assembly in the classroom.

1. Fill, Build-up, and Vent Valve.
2. Converter Vent Quick Disconnect.
3. Liquid Container.
4. Carrying Handle.
5. Converter Supply Quick Disconnect.
6. Container Relief Valve.
7. Probe Lead Connectors.



1F-4C Liquid Oxygen
Converter Assembly

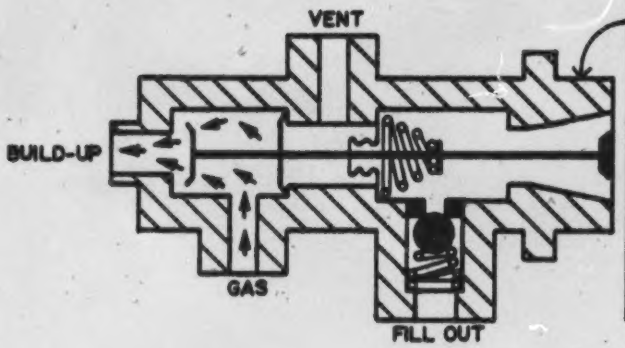
No Response Required.

2777

Answers to Frame 1: No Response Required

Frame 2

The combination fill, build-up, and vent valve is shown below. Here we have the filler valve as part of the build-up and vent valve instead of two separate valves. As shown in the schematic on the left, the normal position of this valve is in build-up. In this position, the gas port (from the top of the container) is open to the build-up port. The build-up port is connected to the pressure opening-pressure closing valve. The "fill out" port on the valve is connected to the bottom of the container. The ball check valve in this port prevents a reverse flow of liquid out through the valve. A protective dust cap attached to a chain is used on the filler port of this valve the same as on the separate filler valve.



Shown in Build-up.

GAS
B.U.
FILL
VENT

Filler, Build-up, and Vent Valve

Select the following statement(s) that is/are true.

_____1. The normal position of the fill, build-up, and vent valve is "build-up."

_____2. The ball check valve in the "fill out" port prevents a reverse flow of liquid oxygen out of the valve.

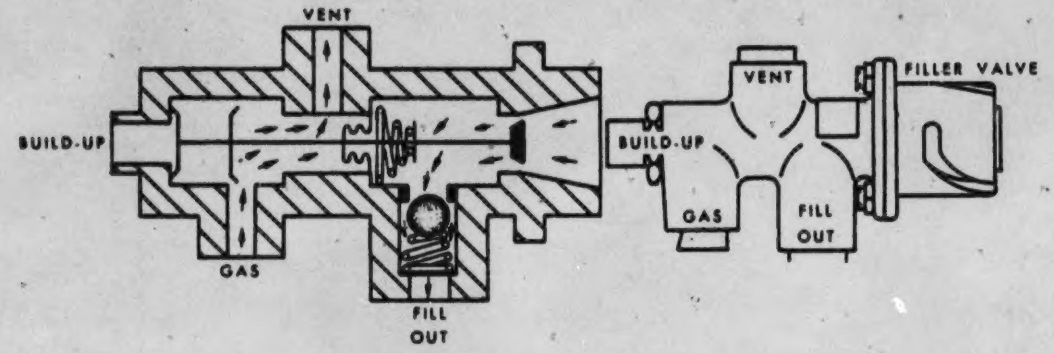
_____3. The gas port is connected to the bottom of the container.

_____4. A dust cap is used on the filler port of the combination fill, build-up, and vent valve.

Answers to Frame 2: 1. T 2. T 3. ___ 4. T

Frame 3

When the filler nozzle from the liquid oxygen servicing trailer is connected to the fill, build-up, and vent valve, it will be in the position shown below. A pin in the filler nozzle pushes the valve shaft forward and closes the build-up port. At the same time, the gas port is opened to the overboard vent and system pressure is discharged overboard. When the liquid flows in under pressure, it unseats the ball check valve in the "fill out" port and goes into the container. When the filler nozzle is removed, the ball check valve reseats, the valve shaft moves out and automatically returns the system to "build-up."



Shown in Fill & Vent.
Combination Fill, Build-up, and Vent Valve.

Select the following statement(s) that is/are true.

_____1. When the filler nozzle is connected, system pressure is vented overboard.

_____2. The normal position of the fill, build-up, and vent valve is "vent."

_____3. When the filler nozzle is removed, the valve returns to "build-up."

_____4. When servicing the system, the incoming liquid unseats the ball check valve in the "fill out" port.

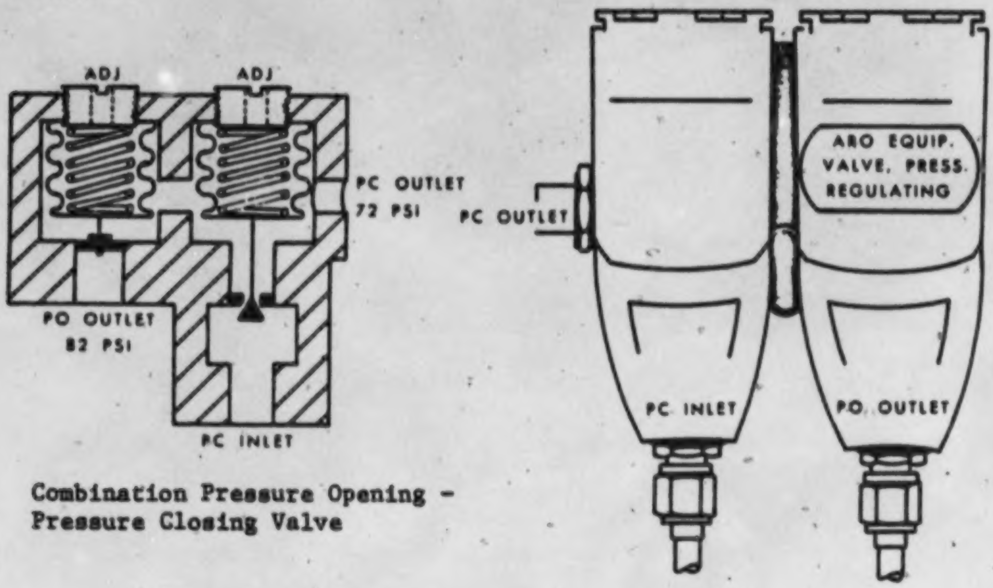
_____5. When the filler nozzle is connected, the valve automatically moves from build-up to vent.

2779

Answers to Frame 3: 1. T 2. ___ 3. T 4. T 5. T

Frame 4

You already know the pressure closing (PC) valve regulates system pressure by controlling the container "head pressure." In this particular F-4 system we have a combination pressure opening pressure closing valve. The primary purpose of the pressure opening (PO) valve is to conserve gaseous oxygen that is normally vented overboard by the relief valve. The pressure opening valve is used only in low pressure (70 psi) liquid systems. As shown below, both of these valves are bellows operated pressure regulating valves contained in one housing. The pressure closing (PC) portion of this valve is normally open and closes at 72 psi. The pressure opening (PO) portion of this valve is normally closed and opens at 82 psi. When the pressure opening valve opens at 82 psi, gaseous oxygen is drawn directly from the top of the container for breathing. This valve is part of the converter assembly.



Combination Pressure Opening -
Pressure Closing Valve

Select the following statement(s) that is/are true.

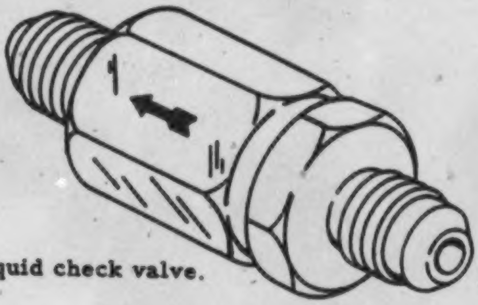
_____1. The pressure opening-pressure closing valves are bellows operated.
_____2. The pressure closing valve regulates system pressure at 72 psi.
_____3. The pressure opening valve opens at 82 psi.
_____4. The pressure opening valve is normally open.
_____5. When the pressure opening valve opens, gaseous oxygen is taken from the top of the container.
_____6. The pressure opening-pressure closing valve is part of the converter assembly.
_____7. The purpose of the pressure opening valve is to conserve gaseous oxygen.
_____8. A pressure opening valve is used only on low pressure liquid systems.

2780

Answers to Frame 4: 1. T 2. T 3. T 4. ___
5. T 6. T 7. T 8. T

Frame 5

The liquid check valve separates the liquid and gaseous phase of operation and prevents a reverse flow. This valve allows liquid to be drawn into the main supply line during normal operating conditions. When operating pressures are excessive, and the pressure opening valve is open, the spring in this check valve creates a 5 psi differential between the gaseous and liquid phase as gaseous oxygen is being drawn off the top of the container. This will close the check valve when the pressure opening valve is open. When we discuss overall system operation, the function of this valve will become clear.



Liquid check valve.

Select the following statement(s) that is/are true.

_____1. The liquid check valve prevents reverse flow.

_____2. This valve separates the liquid and gaseous phase of operation.

_____3. During normal operating conditions, liquid flows through the check valve into the main supply line.

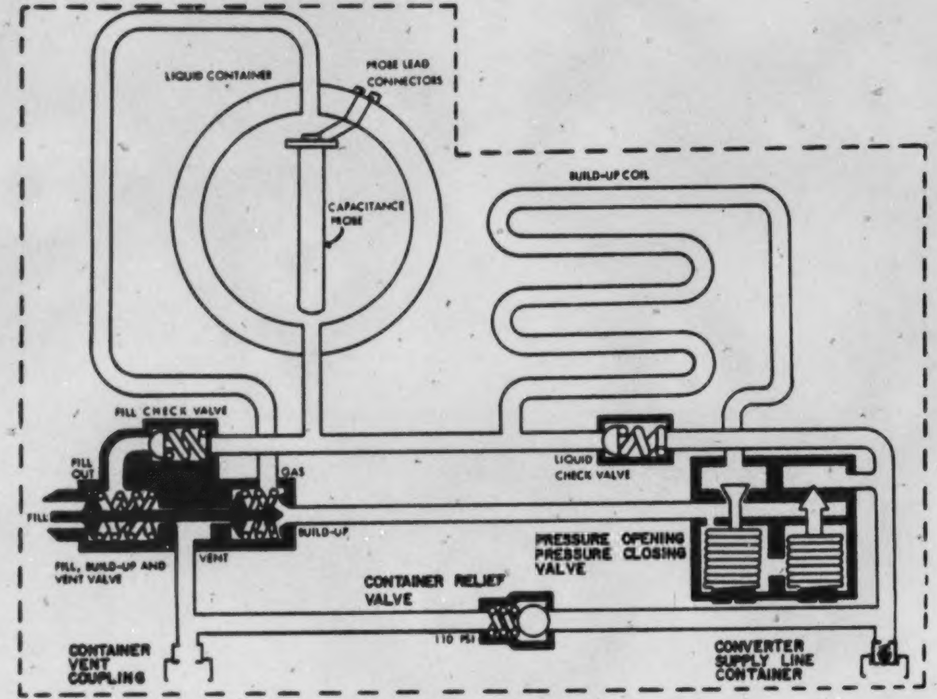
_____4. When the pressure opening valve is open, the liquid check valve is closed.

2781

Answers to Frame 5: 1. T 2. T 3. T 4. T

Frame 6

Let's take a look at a schematic of the complete converter-assembly. Locate the fill, build-up, and vent valve, pressure opening-pressure closing valve, and liquid check valve that we discussed individually. The other units such as the liquid container, build-up coil, and relief valve, are already familiar to you. The capacitance probe inside the container is part of the quantity indicating system which will be covered later. In the schematic, the system is shown empty and the valves in their normal position. Note the converter assembly has only one relief valve which is set at 110 psi. This is the container relief valve.


LIQUID CONTAINER
PROBE LEAD CONNECTORS
CAPACITANCE PROBE
BUILD-UP COIL
FILL CHECK VALVE
FILL OUT
FILL
GAS
BUILD-UP
VENT
FILL, BUILD-UP AND VENT VALVE
LIQUID CHECK VALVE
PRESSURE OPENING PRESSURE CLOSING VALVE
CONTAINER RELIEF VALVE
110 PSI
CONTAINER VENT COUPLING
CONVERTER SUPPLY LINE CONTAINER

F-4C Liquid Oxygen Converter Assembly (Dual Function Valves).

Select the following statement(s) that is/are true.

_____1. The normal position of the fill, build-up, and vent valve is "build-up."
_____2. The pressure opening valve is normally closed and the pressure closing valve is open as shown.
_____3. The container relief valve is set at 110 psi.
_____4. The supply line and vent line are connected to the converter assembly with quick disconnects.
_____5. The spring in the liquid check valve is holding it open.
_____6. The build-up coil is connected to the inlet port of the pressure closing valve.

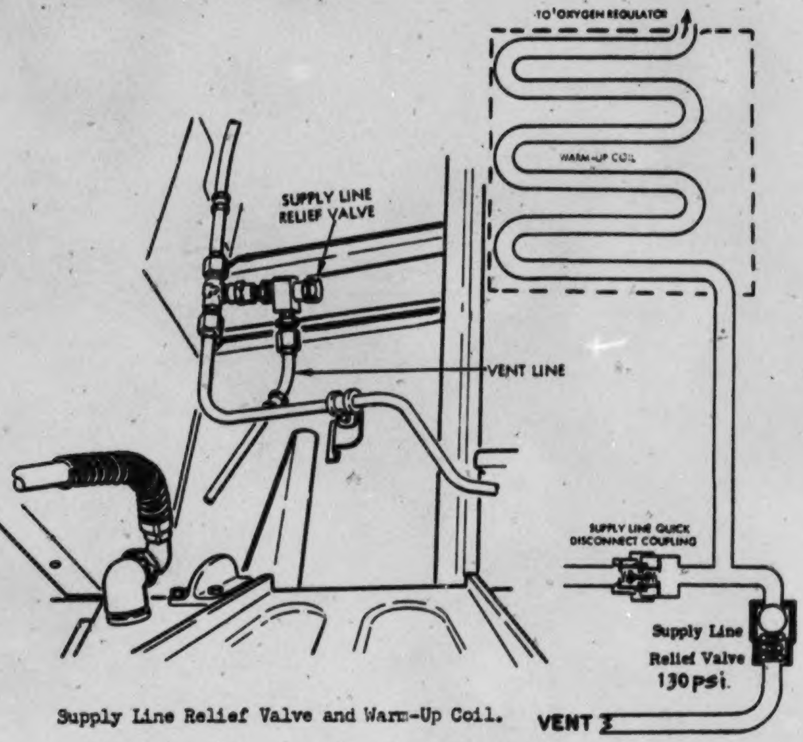
2782

Answers to Frame 6: 1. T 2. T 3. T 4. T 5. ___
6. T

Frame 7

So far we have discussed the converter assembly and its components. Now let's look at the components of the oxygen system that are fixed to aircraft. The supply line relief valve is set at 130 psi and relieves excessive pressure in the supply line and warm-up coil (or warm-up plate). When the converter assembly is removed at the quick disconnects, oxygen is trapped in the supply line and warm-up coil and pressures may become excessive if the temperature changes. The supply line relief valve takes care of this. Also, if the container relief valve fails, the supply line relief valve will take over.

The purpose of the warm-up coil or plate is to raise the temperature of the gaseous oxygen to where it is suitable for breathing. The coil is usually in the cockpit or electronics compartment. Heat in the area surrounding the coil is transferred to the gaseous oxygen as it passes through the coil on its way to the regulators.


TO OXYGEN REGULATOR
WARM-UP COIL
SUPPLY LINE RELIEF VALVE
VENT LINE
SUPPLY LINE QUICK DISCONNECT COUPLING
Supply Line Relief Valve 130 psi.
VENT

Supply Line Relief Valve and Warm-Up Coil.

Select the following statement(s) that is/are true.

_____1. The supply line relief valve is fixed to the aircraft and set at 130 psi.

_____2. As gaseous oxygen passes through the warm-up coil, its temperature rises.

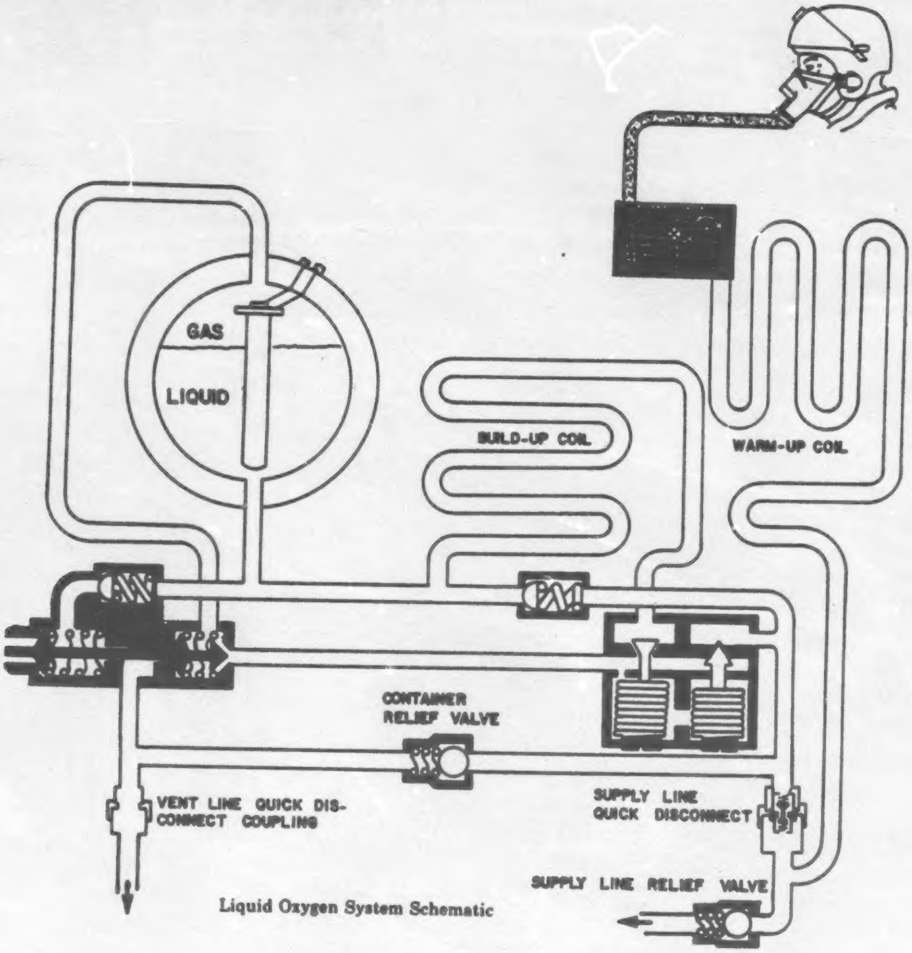
_____3. If the container relief valve fails, the supply relief valve takes over.

2783

Answers to Frame 7: 1. T 2. T 3. T

Frame 8

Now let's take a look at the complete liquid oxygen system we have been discussing in parts. Remember that the supply line relief valve and warm-up coil remain in the aircraft when the converter assembly is removed at the vent line and supply line quick disconnects. The container relief valve stays with the converter assembly.


GAS
LIQUID
BUILD-UP COIL
WARM-UP COIL
CONTAINER RELIEF VALVE
VENT LINE QUICK DISCONNECT COUPLING
SUPPLY LINE QUICK DISCONNECT
SUPPLY LINE RELIEF VALVE

Liquid Oxygen System Schematic

Select the following statement(s) that is/are true.

_____1. The container relief valve is part of the converter assembly.

_____2. The supply line relief valve is part of the converter assembly.

_____3. One end of the build-up coil goes to the pressure closing valve.

_____4. The supply line relief valve has a higher setting than the container relief valve.

_____5. The normal position of the fill, build-up, and vent valve is "build-up."

2784

Answers to Frame 8: 1. T 2. ___ 3. T 4. T 5. T

Frame 9 (Review Frame)

Circle the letter that is in front of what you believe to be the correct response. Check your answers on the top of the next page.

1. What prevents a reverse flow of liquid oxygen out of the fill, build-up and vent valves when the filler nozzle is removed?

   a. Supply line relief valve.
   b. The fill check valve.
   c. Container relief valve.
   d. The liquid check valve.

2. When system pressure becomes excessive, which valve will open and allow gaseous oxygen to be drawn off the top of the container?

   a. Fill, build-up and vent valve.
   b. Pressure closing valve.
   c. Container relief valve.
   d. Pressure opening valve.

3. On the F-4C converter assembly, the pressure opening valve forms a combination with the

   a. filler valve.
   b. liquid check valve.
   c. pressure closing valve.
   d. build-up valve.

4. The F-4C converter assembly contains only the CONTAINER relief valve.

   a. True
   b. False

5. The pressure opening-pressure closing valve is ONLY used

   a. on low pressure (70 psi) liquid oxygen systems.
   b. when a build-up coil is used.
   c. on high pressure (300 psi) liquid oxygen systems.
   d. when no head pressure is required.

6. On the F-4C aircraft, the warm-up coil or plate is part of the converter assembly.

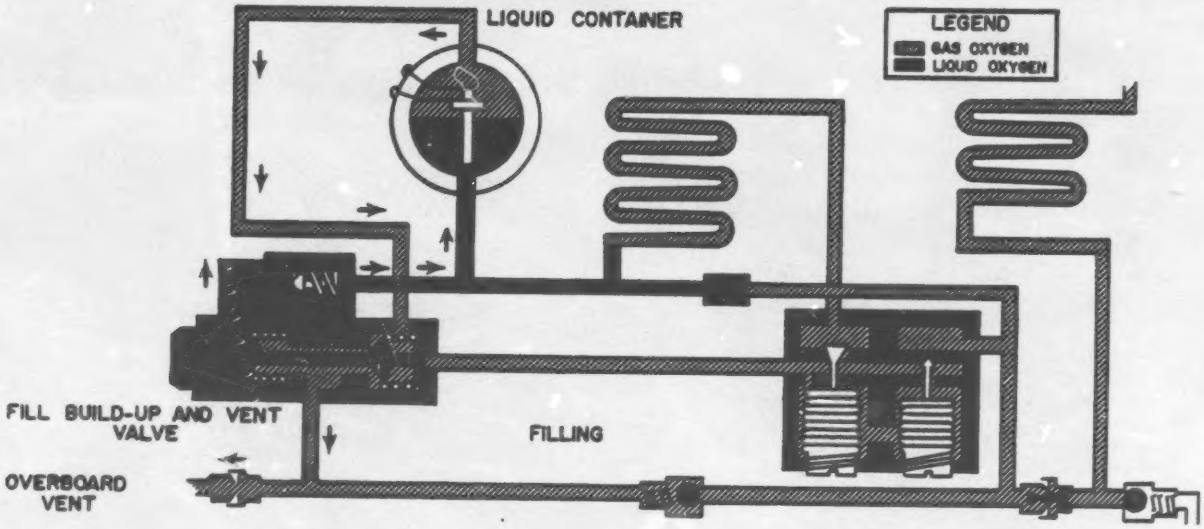
   a. True
   b. False

2785

Answers to Frame 9: 1. b 2. d 3. c 4. a 5. a 6. b

Frame 10

Now that you are familiar with the dual function valves used in this type of system, let's discuss the operation of this system. In order to fully understand what is taking place within the system, it is necessary to look at the system in four (4) different phases of operation. The first phase is FILLING and this is shown below. When the nozzle from the servicing trailer is connected to the fill, build-up and vent valve, the plunger in the valve is pushed in as shown. This closes the build-up line and provides an open line to the overboard vent. Any pressure in the system is now vented overboard. When the liquid oxygen enters the valve, it unseats the fill check valve and goes into the container through the bottom. When the container is full, liquid flows out the top of the container, back through the valve and out the overboard vent. At this time, the nozzle from the servicing trailer is removed and this automatically places the system in the build-up phase.



Select the following statement(s) that is/are true.

_____1. The fill check valve is unseated when filling the system.

_____2. The liquid check valve is closed when filling.

_____3. When filling, the pressure closing valve is open (normal position).

_____4. When filling, liquid oxygen enters the warm up coil.

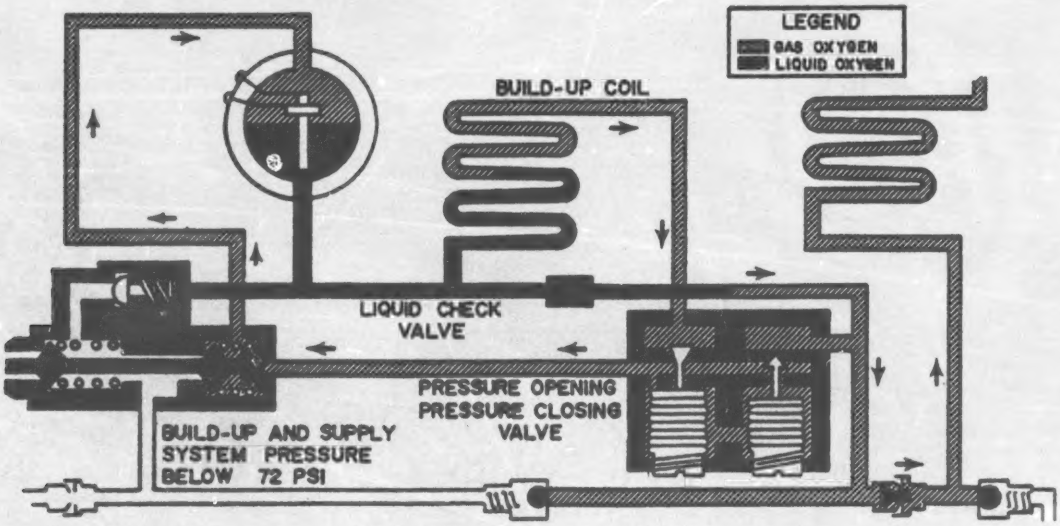
_____5. System pressure is vented overboard when the filling nozzle is connected.

167

Answers to Frame 10: 1. T 2. T 3. T 4. ___ 5. T 2786

Frame 11

Once the transfer hose nozzle is removed, pressure begins to build up in the system. This pressure build-up continues until system pressure reaches 72 psi. The schematic below illustrates this pressure build-up phase. Note that liquid is boiling off in the build-up coil and returning to the top of the container through the pressure closing valve (which is open) and the fill, build-up and vent valve. The container is building up "head" pressure. During this phase, breathing oxygen is obtained from liquid oxygen drawn through the liquid check valve (shown open). This liquid will vaporize as it passes through the supply line and warm up coil on its way to the oxygen regulator.


LEGEND
▨ GAS OXYGEN
■ LIQUID OXYGEN
BUILD-UP COIL
LIQUID CHECK VALVE
PRESSURE OPENING PRESSURE CLOSING VALVE
BUILD-UP AND SUPPLY SYSTEM PRESSURE BELOW 72 PSI

Select the following statement(s) that is/are true.

_____1. When system pressure is below 72 psi the pressure closing valve is closed.

_____2. When the transfer hose nozzle is removed, the system returns to build-up.

_____3. During the build-up phase, the build-up coil is supplying gaseous oxygen which is returned to the top of the container.

_____4. During this phase, liquid oxygen is drawn through the liquid check valve and vaporized in the supply line and warm up coil.

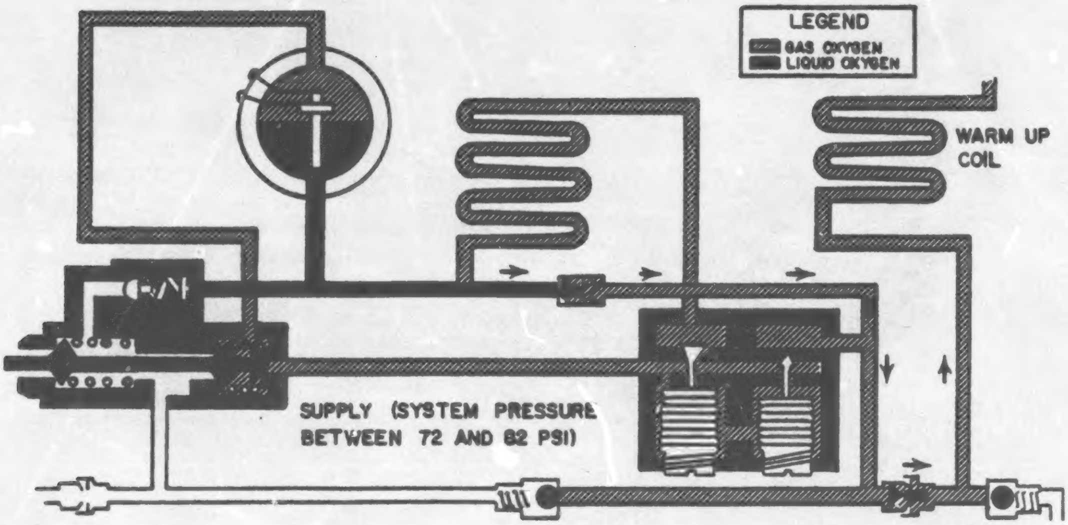
_____5. During this phase, the container relief valve is open.

2787

Answers to Frame 11: 1. ___ 2. T 3. T 4. T 5. ___

Frame 12

In this phase of operation, breathing oxygen is obtained from gaseous oxygen drawn through the liquid check valve. In this condition the pressure closing valve is closed (closed at 72 psi) and the pressure opening valve is still closed (opens at 82 psi). With the pressure closing valve closed, pressure build-up in the system is stopped because the return path to the top of the container is blocked. The liquid trapped in the build-up coil now evaporates (shown evaporated) and causes a back flow of liquid to the container. This action is what enables gaseous oxygen to be drawn through the liquid check valve (see schematic). As the pressure is lowered by the oxygen being used, the pressure closing valve will open and pressure will again build up.



Select the following statement(s) that is/are true.

_____1. When system pressure is between 72 and 82 psi, the pressure closing and pressure opening valves are closed.

_____2. When the pressure closing valve closes, pressure build-up is halted.

_____3. The pressure closing valve is set to close at 52 psi.

_____4. When the pressure closing valve closes, liquid oxygen trapped in the build-up coil will evaporate and cause a back flow.

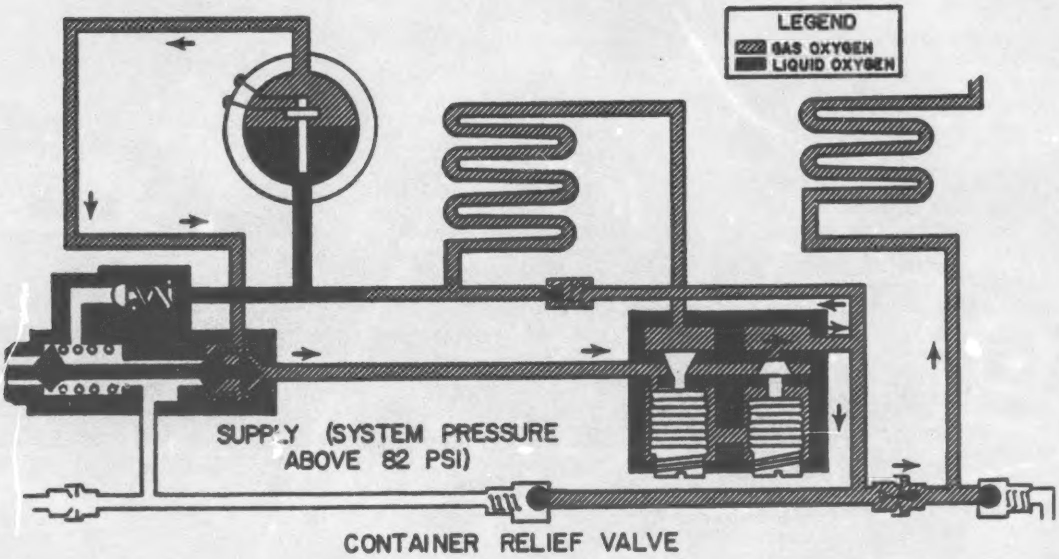
_____5. In this phase, gaseous oxygen for breathing is drawn through the liquid check valve.

2788

Answers to Frame 12: 1. T 2. T 3. ___ 4. T 5. T

Frame 13

In cases where the use of gaseous oxygen is below normal at the regulator (low demand), and repeated cycling of the system causes excessive pressure build-up, the pressure opening valve will open. The pressure opening valve will open at 82 psi as shown below. When this valve opens, gaseous oxygen for breathing is drawn from the top of the container through this valve and out to the warm up coil. The pressure opening valve remains open as long as normal evaporation in the container is adequate to maintain system pressure above 82 psi. With this valve open, a back pressure will close the liquid check valve as shown. This phase of operation continues until system pressure drops below 82 psi again. When the oxygen system is not being used at all, normal evaporation in the container will cause pressure to build up until it reaches the setting of the container relief valve (110 psi). This will vent excess pressure overboard.



Select the following statement(s) that is/are true.

_____1. The pressure opening valve opens at 82 psi.

_____2. A low demand on the system causes pressure to build up.

_____3. When the pressure opening valve is open, breathing oxygen is drawn from the top of the container.

_____4. In this phase, the liquid check valve is open.

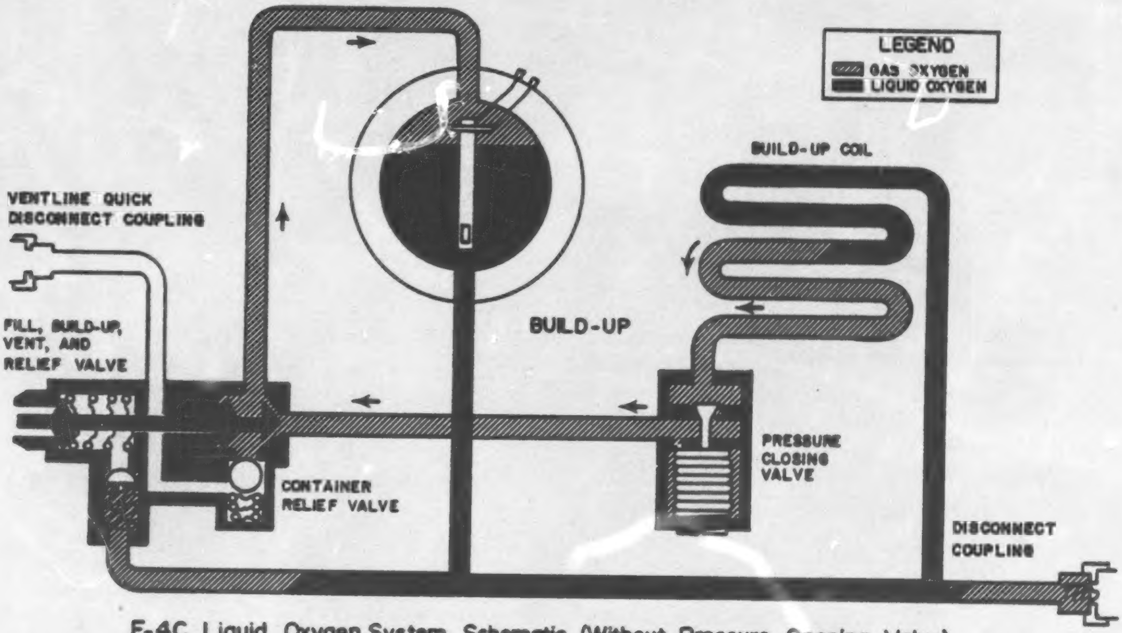
_____5. If no oxygen is being used, pressure will rise to the relief valve setting.

2789

Answers to Frame 13: 1. T 2. T 3. T 4. ___ 5. T

Frame 14

Let's take a look at another type of converter assembly found on the F-4C aircraft. As shown in the schematic, this assembly has a single unit pressure closing valve only. The fill, build-up, and vent valve used in this system has another component built in; this is the container relief valve. So now we have a combination fill, build-up, vent, and relief valve. Note also that this converter assembly does not have a liquid check valve. In operation, liquid oxygen will gravity feed into the build-up coil and change to a gas. This gas goes through the pressure closing valve and up to the top of the container. This pressure build-up continues until the pressure closing valve "closes" at 72 psi. As the "head pressure" on the top of the liquid increases, more liquid is forced out the bottom of the container and evaporates in the supply line and warm up coil on the aircraft. This converter assembly can be placed in the aircraft and connected at the same quick disconnects as the previous converter assembly we have discussed.


LEGEND
▨ GAS OXYGEN
■ LIQUID OXYGEN
BUILD-UP COIL
VENTLINE QUICK DISCONNECT COUPLING
FILL, BUILD-UP, VENT, AND RELIEF VALVE
BUILD-UP
CONTAINER RELIEF VALVE
PRESSURE CLOSING VALVE
DISCONNECT COUPLING

F-4C Liquid Oxygen System Schematic (Without Pressure Opening Valve)

Select the following statement(s) that is/are true.

_____1. In this type of converter assembly the container relief valve is part of the fill, build-up, and vent valve.

_____2. This unit does not have a liquid check valve.

_____3. Only a pressure closing valve is used in this converter assembly.

2790

Answers to Frame 14: 1. T 2. T 3. T

Frame 15

Instructions: The facing page has a schematic of the liquid oxygen system we have been discussing. Use this page to do the following:

Part 1. Identify the components in the system by placing the letters from the arrowed circles by the correct name of that component in the given list. Check your answers on the next page.

Part 2. Draw the necessary valves open or closed (with a black pencil) to indicate the position they would take if the system pressure was above 82 psi. Now use a red pencil and trace in the liquid flow and a blue pencil to show gaseous oxygen flow. Check your tracing against the schematic for this phase of operation in the text.

2791

1.____Vent Quick Disconnect.

2.____Fill,Build-Up,and Vent Valve.

3.____Fill Check Valve.

4.____Liquid Container.

5.____Build-Up Coil.

6.____Liquid Check Valve.

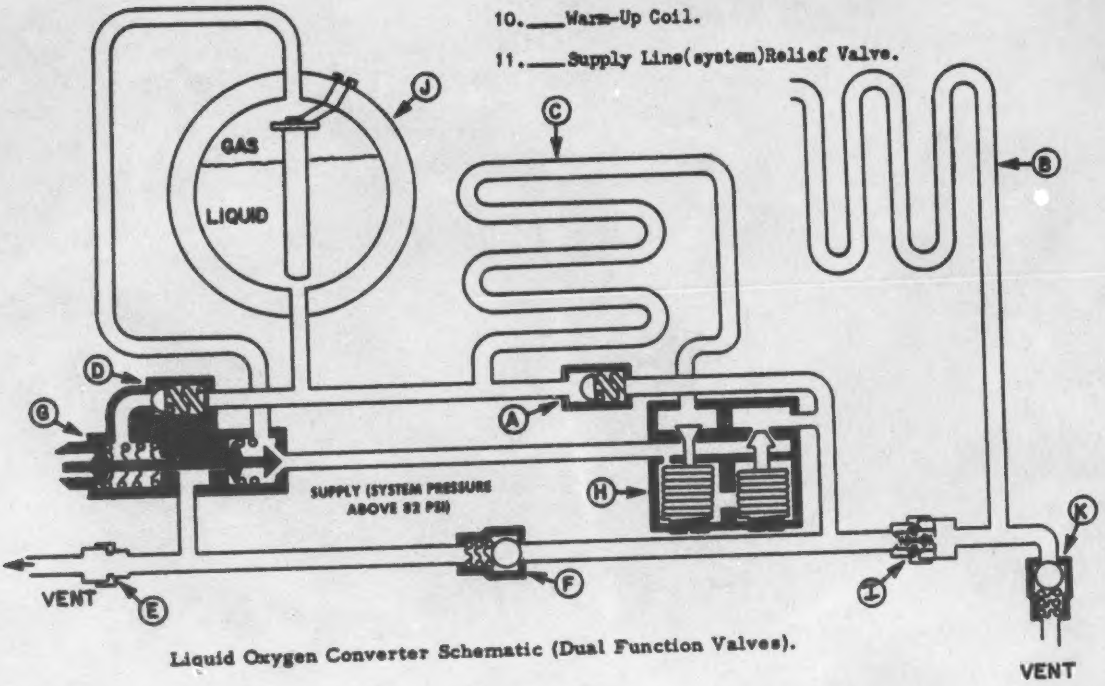
7.____Pressure Opening-Pressure Closing Valve.

8.____Container Relief Valve.

9.____Supply Quick Disconnect.

10.____Warm-Up Coil.

11.____Supply Line(system)Relief Valve.


J
GAS
LIQUID
C
B
D
G
A
H
SUPPLY (SYSTEM PRESSURE ABOVE 82 PSI)
F
VENT
E
I
K
VENT

Liquid Oxygen Converter Schematic (Dual Function Valves).

Answers to Frame 15: (Part 1) 1. E 2. G 3. D 4. J 5. C 6. A
7. H 8. F 9. I 10. B 11. K

2792

PROGRAMMED TEXT

3ABR42331-PT-402C

Technical Training

Aircraft Environmental Systems Mechanic

LIQUID OXYGEN QUANTITY INDICATING SYSTEMS

20 November 1978

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.

Do Not Use on the Job.

2793

FOREWORD

This programmed text was designed for use in Course 3ABR42331. The material herein has been validated with 30 students from the subject course. All students achieved the objectives as stated. Average time for completion of the text was 35 minutes.

OBJECTIVES

After completion of this programmed text you will be able to:

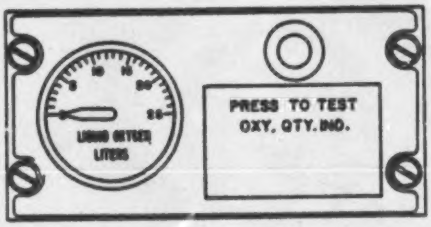
1. Relate four (4) of five (5) liquid oxygen quantity indicating components with their purpose.

INSTRUCTIONS

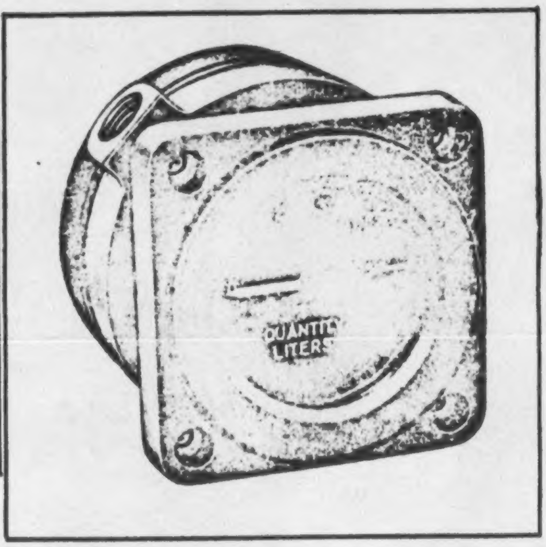
Throughout this programmed text you will be required to respond to the information given. After making your response, check the correct answer at the top of the following page. If your response was incorrect review the frame to determine your error before proceeding to the next frame.

Supersedes 3ABR42231-PT-314C, 16 December 1970.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 600; TTVSA - 1.

All liquid oxygen systems have some types of quantity indicating system to let the pilot, or whoever is using the oxygen, know how much he has remaining in the liquid container. There are three (3) types of indicating systems used with liquid oxygen convertors: 1. The direct reading, differential-pressure contents gage (shown on right below). 2. The electrical-differential pressure contents gaging system. 3. The capacitance contents gaging system (shown on left). Regardless of the types of indicating system used, all the gages are read in liters of liquid oxygen. The total number of liters which the gage indicates (5-25-75, etc.) depends upon the size of the liquid container on the convertor assembly being used. The three indicating systems mentioned above will be discussed in this text.



LIQUID OXYGEN QUANTITY INDICATOR PANEL



LIQUID OXYGEN CONTENTS GAGE

Mark the following statements with a T for True or an F for False.

_____1. Quantity gages indicate in liters of liquid oxygen.

_____2. The three types of indicating systems used are the direct reading, electrical-differential pressure, and capacitance type system.

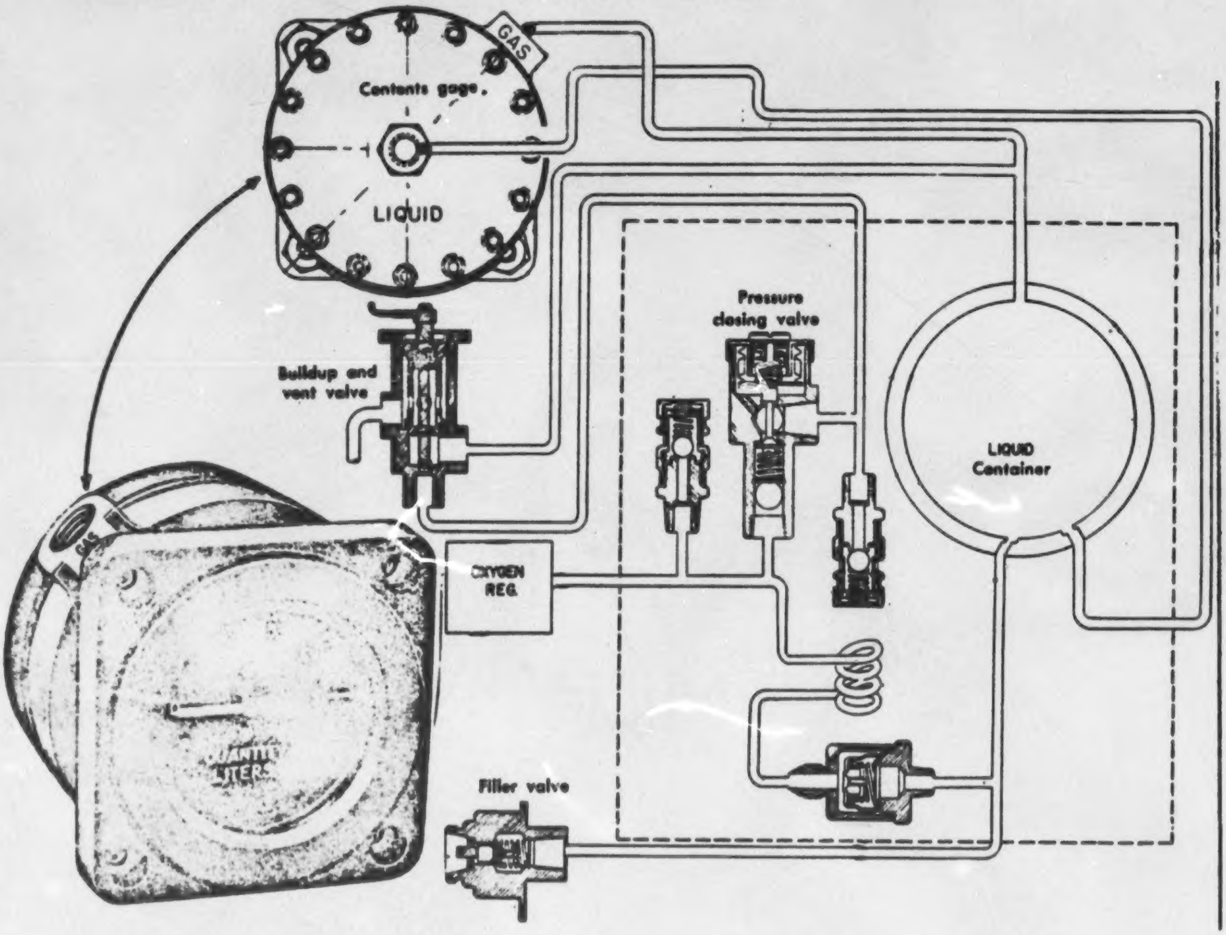
_____3. If the convertor assembly has a 5 liter container, the quantity indicator would read a total of 5 liters.

_____4. All liquid oxygen systems have a quantity indicating system of some type.

Answers to Frame 1: 1. T 2. T 3. T 4. T

Frame 2

The first quantity indicating system we will discuss is the direct reading type shown below. It is referred to as "direct reading" because it is connected to the container with tubing and no electrical connections are required. As shown in the illustration, we have one line coming off the bottom of the container going to the liquid connection on the back of the unit. The line coming off the top of the container goes to the gas connection on the back of the unit. Note also the gas line to the build-up and vent valve is tapped off this line. This quantity gage is located in the cockpit usually next to the oxygen regulator.


GAS
Contents gage.
LIQUID
Buildup and vent valve
Pressure closing valve
LIQUID Container
OXYGEN REG.
Filler valve
GAS
QUANTITY LITERS

Direct Reading, Differential-Pressure Contents Gage Installation.

Mark the following statements with a T for True or an F for False.

_____1. The direct reading quantity gage is connected directly to the liquid container with tubing.

_____2. This gage has two connections; gas and liquid.

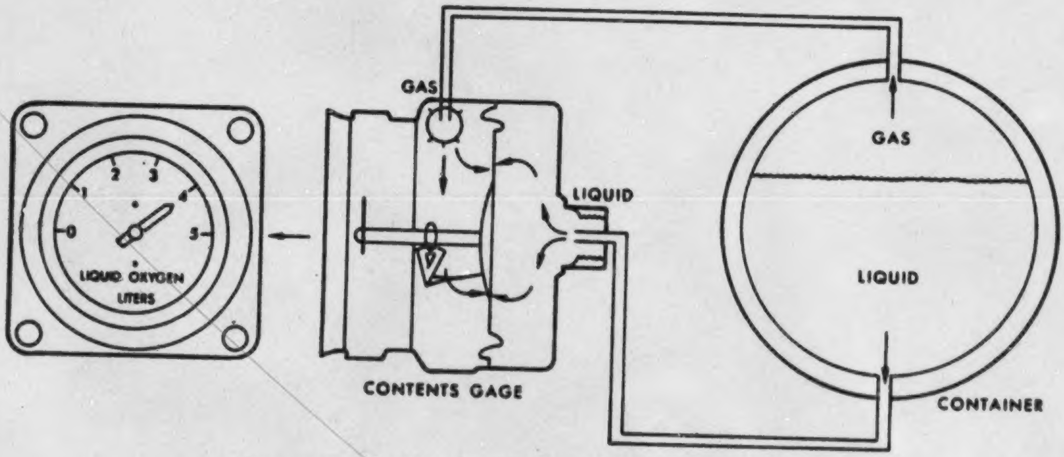
_____3. The direct reading contents gage operates by electricity.

_____4. The quantity gage is located in the cockpit.

Answers to Frame 2: 1. T 2. T 3. F 4. T

Frame 3

The direct reading contents gage has two chambers separated by a diaphragm. Notice below that gas pressure from the top of the container is applied to one side of the diaphragm. On the opposite side of the diaphragm, we have the pressure on top of the liquid PLUS the weight of the liquid applied. The weight of the liquid then sets up the differential pressure. This differential pressure positions the diaphragm and through mechanical linkage, positions the indicator pointer. Note the connection on the back of the gage is labeled "liquid." However, oxygen in a liquid state does not reach the gage. Liquid leaves the container but changes to a gas as it travels through the tubing. The direct reading, differential pressure quantity indicating system is the most simple of the systems we will discuss. However, it's not often used because of the disadvantage of the long tubing runs from the container to the indicator.



Direct Reading Contents Gage Schematic.

Mark the following statements with a T for True or an F for False.

_____1. The weight of the liquid determines the amount of differential pressure.

_____2. Oxygen in a liquid state is applied to one side of the diaphragm.

_____3. This type of system is not often used because of the long tubing runs.

_____4. The pointer on the gage is positioned through mechanical linkage.

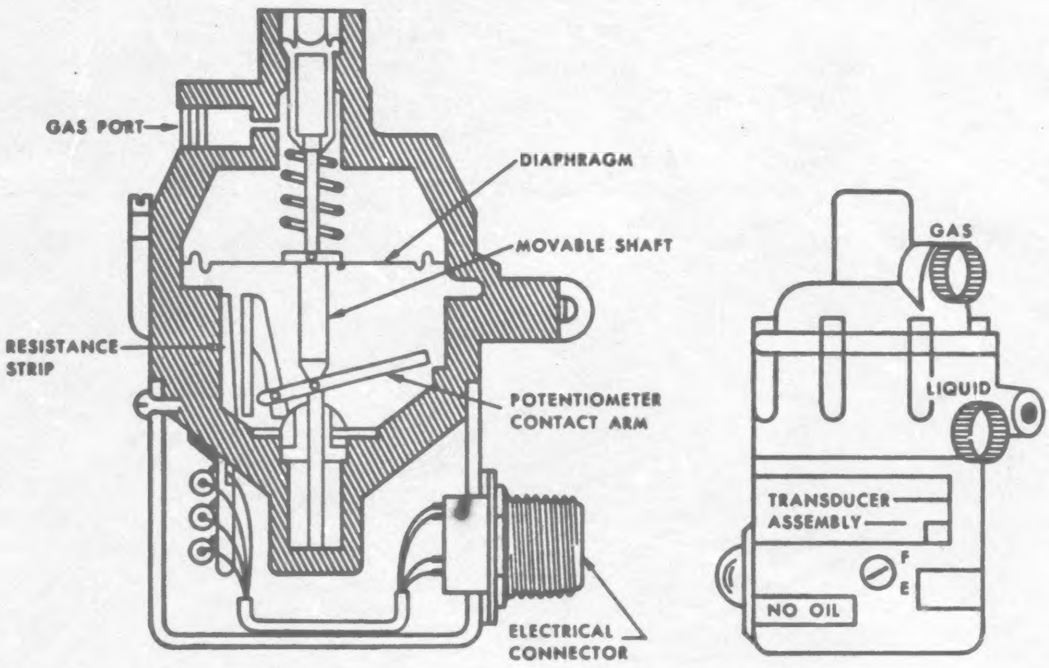
_____5. The direct reading contents gage has two chambers separated by a diaphragm.

2797

Answers to Frame 3: 1. T 2. F 3. T 4. T 5. T

Frame 4

The next system we will discuss is the electrical-differential pressure contents gaging system. This system is composed of two basic units, the transducer assembly and the quantity indicator. The transducer used in this system is shown below. Generally speaking, a transducer is any device that changes one type of signal to another. In our case, we want to convert the pressure differential (as discussed in the direct reading system) to an electrical signal. The transducer shown will do this job. When the transducer converts the pressure signal to an electrical signal, it sends it to the indicator which provides a readout in liters on its dial. The transducer is located on or near the convertor assembly and connects to the container with tubing at the GAS and LIQUID ports.



Transducer Assembly Schematic.

Mark the following statements with a T for True or an F for False.

_____1. A transducer changes one type of signal to another.

_____2. In this system, the transducer changes the differential pressure signal to an electrical signal.

_____3. The indicator reads out the electrical signal in liters of oxygen.

_____4. The transducer is located on the pilot's instrument panel.

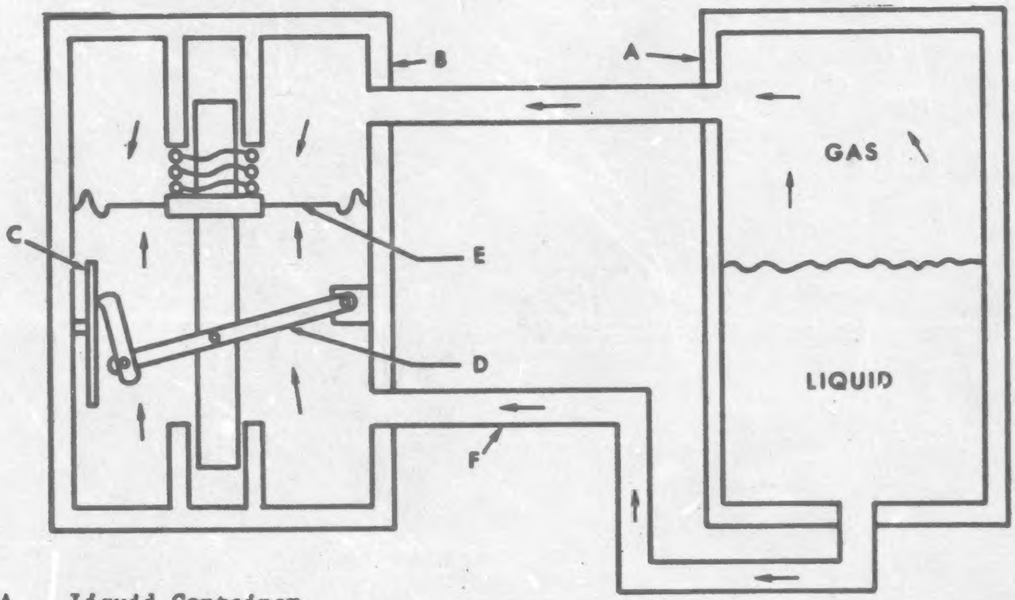
_____5. The two major units in the electrical-pressure differential contents gaging system are the transducer and indicator.

2798

Answers to Frame 4: 1. T 2. T 3. T 4. F 5. T

Frame 5

Let's take a look at a simplified schematic of the transducer and determine how the mechanical portion of this unit operates. The transducer (B) operates on the differential pressure created in the liquid container (A). Here we have gas pressure from the top of the container acting on one side of the diaphragm (E), and gas pressure PLUS the weight of the liquid acting on the other (bottom) side of the diaphragm. The movement of the diaphragm (E) positions the contact arm (D) on the resistance strip (C). Note the contact arm (or wiper arm) is connected to the movable shaft which in turn is connected to the diaphragm. As the liquid level changes in the container, the differential pressure will change and the diaphragm varies the contact arm accordingly. The indicator, which is electrically connected to the resistance strip, will pick up this varying signal and move its indicating pointer.



A.	Liquid Container.		
B.	Transducer Assy.		
C.	Resistance Strip.	E.	Diaphragm.
D.	Contact Arm.	F.	Tubing.

Mark the following statements with a T for True or an F for False.

_____1. As the liquid level changes. the differential pressure will change.

_____2. The indicator is connected electrically to the resistance strip.

_____3. The contact arm varies the resistance sent to the indicator.

_____4. The weight of the liquid determines the differential pressure.

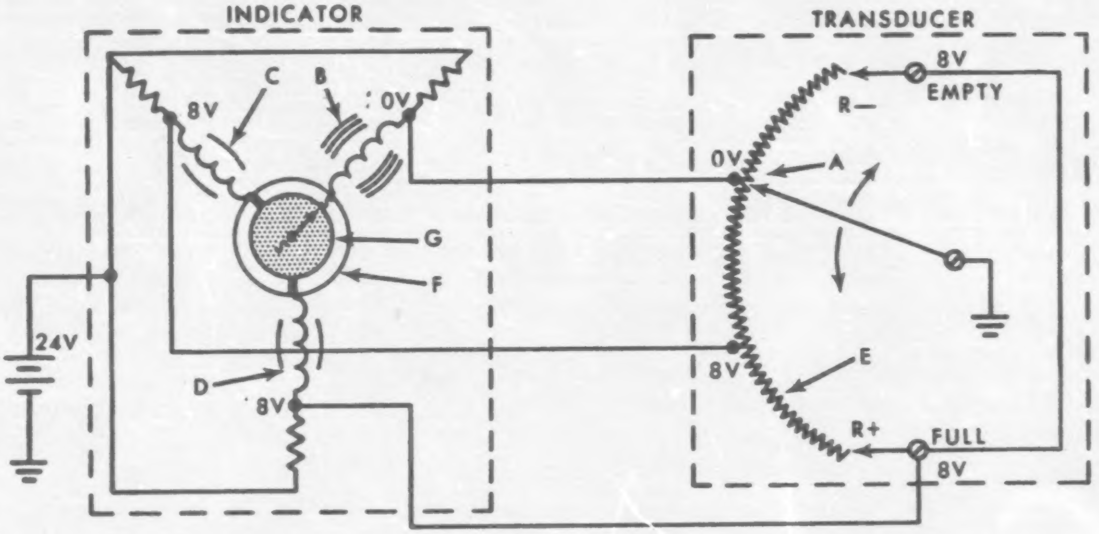
_____5. The contact arm can move up or down the resistance strip.

2799

Answers to Frame 5: 1. T 2. T 3. T 4. T 5. T

Frame 6

Let's discuss the electrical circuit of the indicator and transducer as shown below. This type of liquid indicating system is sometimes referred to as a "Selsyn" system in technical publications. Selsyn is a trade name used by a particular manufacturer that makes this type of "three wire" liquid gaging circuit and simply means the system has self-synchronous instruments and they are DC operated. In operation, the wiper contact arm (A) in the transducer is positioned on the curved resistance strip (E) by movement of the transducer diaphragm. The current flow in each of the three coils (B-C-D) is determined by the position of the wiper contact arm and the applied voltage. The position of the rotor (G) depends upon the proportion of current flowing in each coil. Note that with the wiper contact arm positioned as it is, a strong magnetic field exists around coil (B) in comparison to the other two coils. Therefore, the permanent magnet rotor (G) is pulled around to align itself with coil (B). The indicator pointer now gives a read-out in liters of liquid oxygen.



A. Wiper Contact Arm.
B. Differential Coil.
C. Differential Coil.
D. Differential Coil.
E. Resistance Strip.
F. Coil Connecting Wire.
G. Permanent Magnet Rotor.

Mark the following statements with a T for True or an F for False.

_____1. When the wiper contact arm moves, the current is varied in the differential coils.

_____2. DC voltage moves the wiper contact arm in the transducer.

_____3. The rotor (G) is positioned by the proportion of current flowing in each coil.

_____4. Selsyn is a trade name for this type of three wire liquid gaging system.

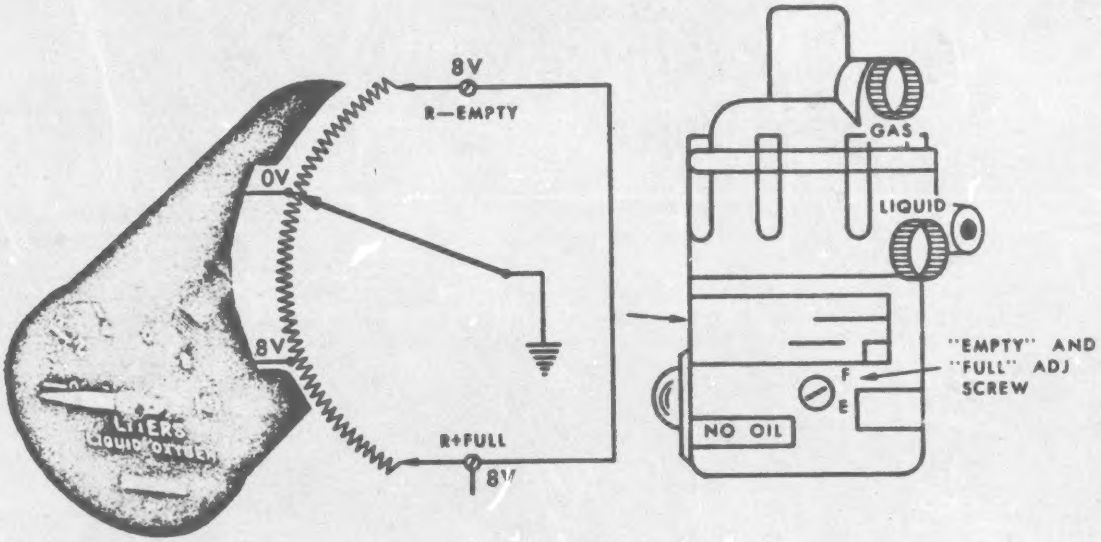
_____5. This system contains self-synchronous, DC operated instruments

2800

Answers to Frame 6: 1. T 2. F 3. T 4. T 5. T

Frame 7

In order to obtain an accurate indication of the number of liters in the container at each end of the scale (full-empty), it's usually necessary that the transducer and indicator be a "matched set." That is, the transducer should be calibrated while connected to the indicator with which it is to be installed in the aircraft. The adjustments for the FULL and EMPTY arrows are accomplished by turning the adjustment screw on the transducer assembly as indicated below. When this screw is turned in one direction, resistance will be varied at R - or the EMPTY end of the resistance strip. When turned in the opposite direction, resistance is varied at R+ or the FULL end of the resistance strip. In other words, if you know the liquid container is completely empty, the resistance can be varied to make the indicator read empty.



INDICATOR TRANSDUCER

Mark the following statements with a T for True or an F for False.

_____1. The indicator and transducer should be calibrated together for accuracy.

_____2. When the adjustment screws are turned, resistance is varied at R- or R+.

_____3. If the liquid container is full, the indicator should read empty.

_____4. All adjustments are made on the transducer assembly.

_____5. These units can be calibrated in the shop or on the aircraft.

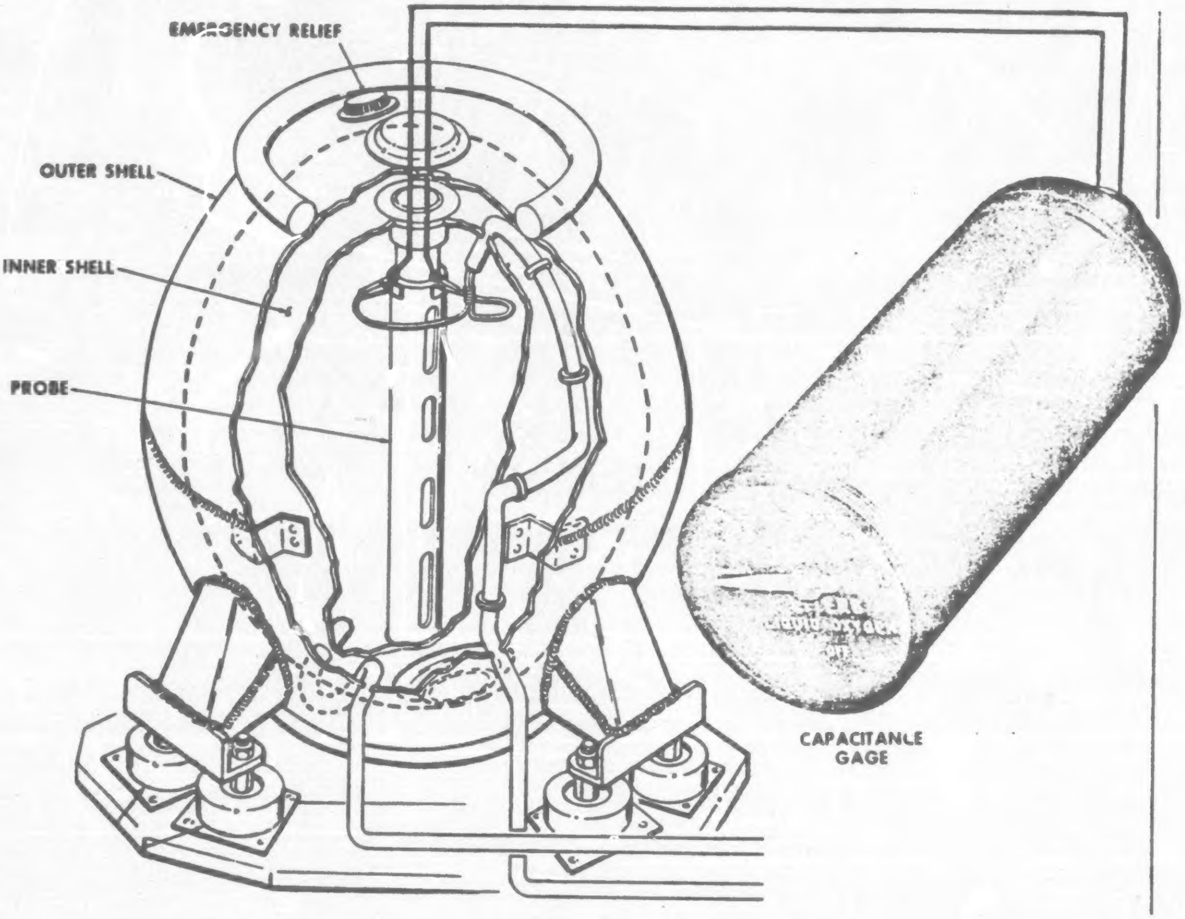
_____6. The transducer is connected to the liquid container with tubing.

2801

Answers to Frame 7: 1. T 2. T 3. F 4. T 5. T 6. T

Frame 8

The last quantity indicating system we will discuss is the capacitance type contents gaging system. This system is probably used more than both the other two systems we have discussed. This indicating system does not require tubing or diaphragms which add weight and cause maintenance problems. Simply stated, the capacitance probe inside the liquid container (see below) acts as a variable capacitor as the liquid level changes. This varying signal is picked up by the capacitance gage (shown) which contains the indicating circuit.



Capacitance Type Contents Gaging System.

Mark the following statements with a T for True or an F for False.

____1. The capacitance probe acts as a variable capacitor.

____2. The probe is installed inside the liquid container.

____3. This indicating system does not contain tubing or diaphragms.

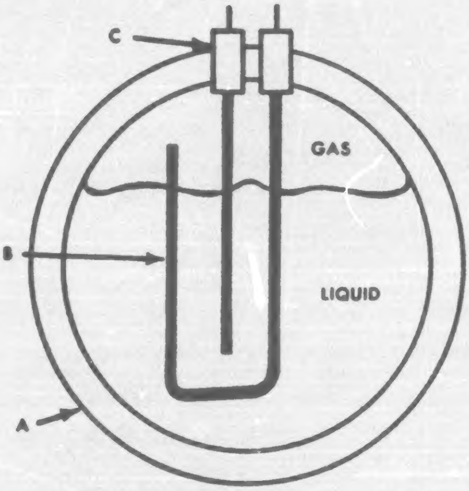
____4. As the liquid level changes, the capacitance signal changes.

____5. The indicating circuit is inside the capacitance probe.

Answers to Frame 8: 1. T 2. T 3. T 4. T 5. F

Frame 9

If you recall from previous instruction, a capacitor consists of two conducting plates with an insulating material separating them. This insulating material is called the dielectric. Materials such as glass, air, mica, wax paper, and oil are commonly used as dielectrics. In this particular case, we are using liquid oxygen as the dielectric between the two plates of the probe as shown below. The amount of capacitance stored in the plates depends upon the plate area, distance between the plates, and the type of dielectric used. As the liquid level changes, we have a variable dielectric between plates of the probe. This generates a varying capacitance signal which is passed on to the indicating circuit.



A. Container B. Plates C. Probe
CAPACITANCE PROBE

Mark the following statements with a T for True or an F for False.

_____1. The capacitance probe consists of two conducting plates.

_____2. The liquid oxygen is used as a dielectric.

_____3. The capacitance probe is installed in the container.

_____4. The insulating material used for all capacitors is oil.

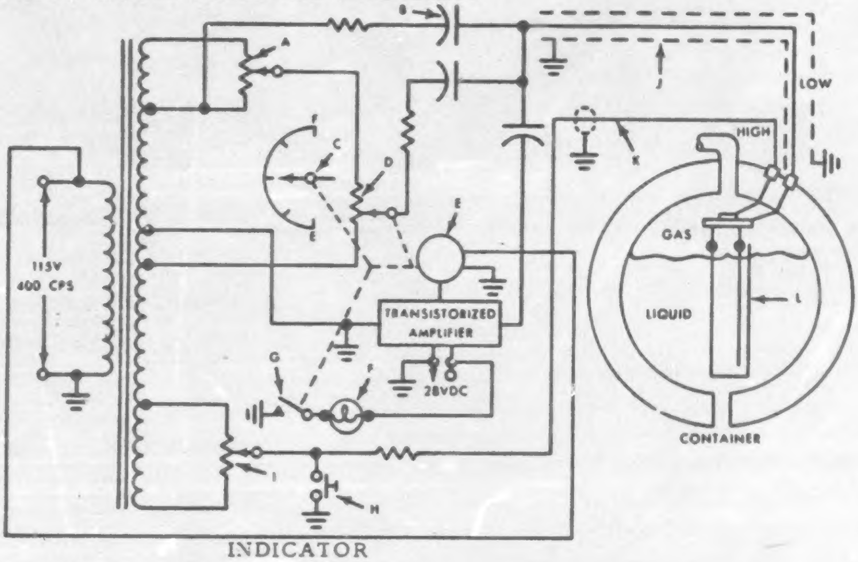
_____5. As the liquid level changes, a varying capacitance signal is generated.

2803

Answers to Frame 9: 1. T 2. T 3. T 4. F 5. T

Frame 10

The capacitance indicating circuit is shown below. Keep in mind these components are miniaturized and contained inside the indicator or capacitance gage. The indicating circuit is primarily a capacitance bridge circuit in which the probe (L) in the container makes up one leg. In operation, the capacitance bridge measures probe (L) capacitance by comparing it to a known reference capacitor (B). When the bridge becomes unbalanced due to a liquid level change in the container, the induction motor (E) receives power and corrects the indicator pointer (C) by mechanical linkage (dotted lines). At the same time, the motor (E) corrects the balancing potentiometer (D). It will also close the low-level switch (G) and send power to the low-level light (F) if the pointer moves to the empty end of the scale. Identify all the components listed below the schematic.



A. Full Adj. Potentiometer
B. Reference Capacitor
C. Indicator Pointer
D. Balancing Potentiometer
E. Induction Motor
F. Low-level Light
G. Low-level Switch
H. Push-to-test Switch
I. Empty Adj. Potentiometer
J. Coaxial Cable
K. Shielded Electrical Lead
L. Capacitance Probe

CAPACITANCE INDICATING CIRCUIT

Mark the following statements with a T for True or an F for False.

_____1. The capacitance indicating circuit is primarily a bridge circuit.

_____2. The bridge circuit compares probe capacitance with a reference capacitor.

_____3. The indicator pointer is moved by mechanical linkage.

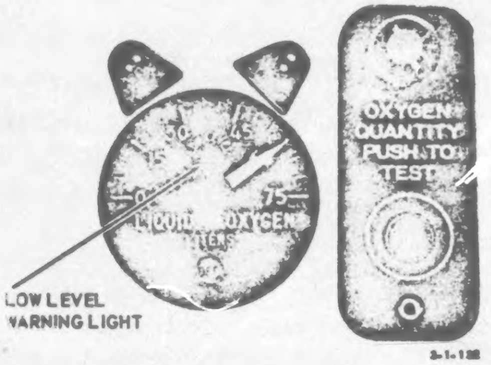
_____4. The probe makes up one leg of the capacitance bridge.

2804

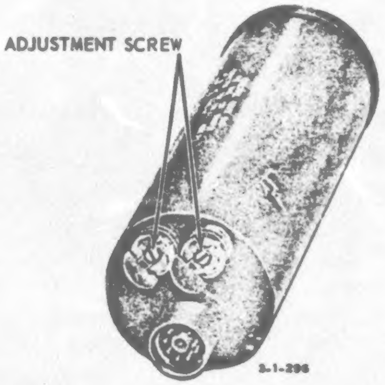
Answers to Frame 10: 1. T 2. T 3. T 4. T

Frame 11

Two of the items we did not discuss in the schematic in Frame 10 are the two adjustments that can be made on the indicator. The full adjustment potentiometer ("A" in the schematic) and the empty adjustment potentiometer ("I" in the schematic). These two potentiometers are connected at opposite ends of the transformer secondary winding shown in the schematic. They provide a means of adjusting the bridge voltages to balance over the empty-to-full capacitance range of the system. The adjustment screws are accessible at the back of the indicator as shown on the right below. The low-level warning light on the face of the indicator warns against complete exhaustion of the oxygen supply. The particular indicator shown below has a power failure "flag" in the lower center of the dial. The oxygen quantity push-to-test switch shown below (located on the indicator panel) is used to check system operation. When the switch is pushed, the bridge is unbalanced and the motor drives the indicator pointer to "empty." When the switch is released, bridge balance is restored and the pointer returns to its original position. This response by the indicator proves that the system is operating normally.



3-1-128



3-1-296

LIQUID OXYGEN CAPACITANCE INDICATOR

Mark the following statements with a T for True or an F for False.

_____1. Adjustments to the quantity indicating system are made on the indicator.

_____2. Adjustments to the system are made on the capacitance probe.

_____3. The push-to-test switch is used to check system operation.

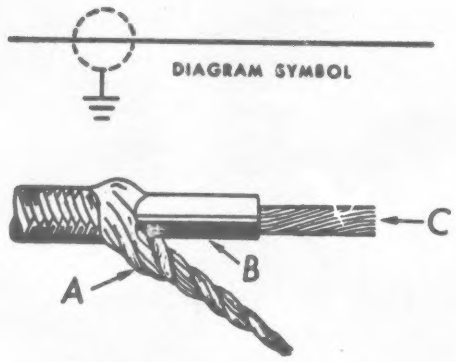
_____4. The low-level warning light warns against complete exhaustion of the oxygen supply.

2805

Answers to Frame 11: 1. T 2. F 3. T 4. T

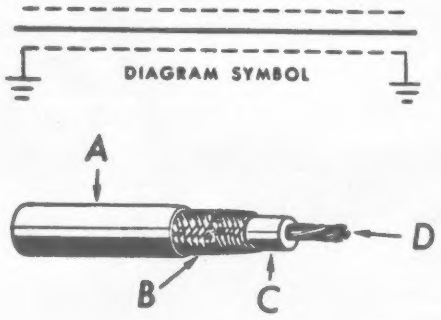
Frame 12

In the capacitance indicating circuit in Frame 10 we have two wires connecting the capacitance probe to the indicator. On the "low" side of the probe we are using a coaxial cable for this connection. This type of cable is illustrated on the right below. Coaxial cable is used on this side of the probe to prevent picking up stray signals which would upset the bridge circuit in the indicator. The wire connecting the "high" side of the probe to the indicator is a shielded electrical lead as shown on the left below. This is the 400 cycle power supply to the probe. This wire does not transmit a signal, so coaxial cable is not required. The wiring diagram symbol for these two wires are shown above each illustration.



A. SHIELDED BRAID C. WIRE
B. INSULATION

Shielded Electrical Lead



A. OUTER INSULATION C. INSULATION
B. COPPER MESH D. SIGNAL WIRE

Coaxial Cable

Mark the following statements with a T for True or an F for False.

_____1. Coaxial cable will transmit a true signal.

_____2. Coaxial cable is used on the "low" side of the capacitance probe.

_____3. The wiring diagram symbol is the same for both cables shown.

_____4. The shielded electrical lead is used on the "high" side of the capacitance probe.

_____5. The shielded lead is used to carry power to the capacitance probe.

2006

Answers to Frame 12: 1. T 2. T 3. F 4. T 5. T

Frame 13

As we mentioned previously, the capacitance indicating system is more accurate and reliable than the direct reading or transducer operated indicating systems. The most frequent trouble with the capacitance indicating system is water (moisture) in the container. Moisture can cause a short between the probe plates or cause an erroneous read-out on the indicator. This is because water (moisture) has a different dielectric effect than liquid oxygen on the capacitance probe.

Mark the following statements with a T for True or an F for False.

_____1. The capacitance indicating system is more reliable than the other two systems we discussed.

_____2. Water (moisture) has a different dielectric effect than liquid oxygen on the capacitance probe.

_____3. Moisture on the probe plates can cause an erroneous read-out on the indicator.

REMEMBER YOUR OXYGEN SAFETY

Answers to Frame 13: 1. T 2. T 3. T

2807

APROGRAMMED TEXT
3ABR42331-PT-402D

Technical Training

Aircraft Environmental Systems Mechanic

OXYGEN SYSTEMS SERVICING AND EQUIPMENT

1 August 1978

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

2808

FOREWORD

This programmed text was prepared for use in the 3ABR42331 instructional system.

OBJECTIVES

After completing this programmed text, you will be able to:

1. Relate four (4) of five (5) oxygen system servicing equipment components with their purpose.

INSTRUCTIONS

This programmed text presents material in small steps called "frames." After each frame you will find a number of statements and you are asked to select the statement/s that are true or mark true and false. Read the material in each frame before making a selection. The answers to each frame can be found at the top of the next page. If you select the correct answers, continue to the next frame. If you are wrong or in doubt, read the material again and correct yourself before continuing.

Note: Upon completion of this programmed text you will use the equipment covered in this text while doing your oxygen lab projects workbook.

Supersedes 3ABR42231-PT-315, 16 July 1971.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370TCHTG/TTGU-P - 600; TTVSA - 1

Frame 1

The TTU-28/E master oxygen test gage is used when performing pressure leak tests on a liquid oxygen system. The unit consists of a 0-400 psi test gage, a gaseous oxygen filler valve, and a liquid oxygen filler valve adapter. When attached to the filler valve of a liquid oxygen system, it opens the system so that you can fill the system with gaseous oxygen. The gaseous oxygen filler valve is of the quick disconnect type and the servicing hose is released from it by moving the handle clockwise.

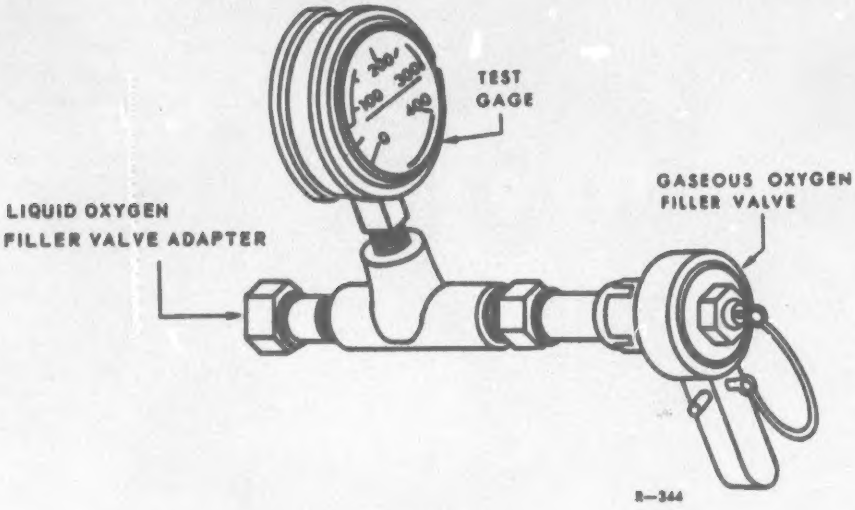

TEST GAGE
100
200
300
400
0
LIQUID OXYGEN FILLER VALVE ADAPTER
GASEOUS OXYGEN FILLER VALVE
R-344

Figure 1. Master Oxygen Test Gage TTU-28/E.

Mark the following statements with a T for True or an F for False.

_____1. The TTU-28/E is attached to the filler valve of a liquid oxygen system.

_____2. The servicing hose is released from the gaseous oxygen filler valve by pulling it out.

2810

Answers to frame 1: 1. T 2. F

Frame 2

The ultrasonic leak detector is also known as an ultrasonic translator. It is a completely transistorized, battery operated instrument that detects sounds within the ultrasonic frequency range and converts them into sounds audible to the human ear. Audible sounds within the normal hearing range are not picked up by this instrument. Other than normal background hiss, the only sounds that are heard from the loudspeaker are ultrasonic sounds that have been converted to audible sounds. The unit is portable and has a shoulder carrying strap. The major components are two probes, a lead assembly for attaching probes to the detector, a rubber adapter that reduces the area of coverage of the probe, and a headset. The headset provides a means of listening when plugged in by cutting out the loudspeaker. On the front panel of the unit are three plug-in jacks, a volume control, an OFF-ON toggle switch, and a meter. The meter indicates the level of sound output in decibles.

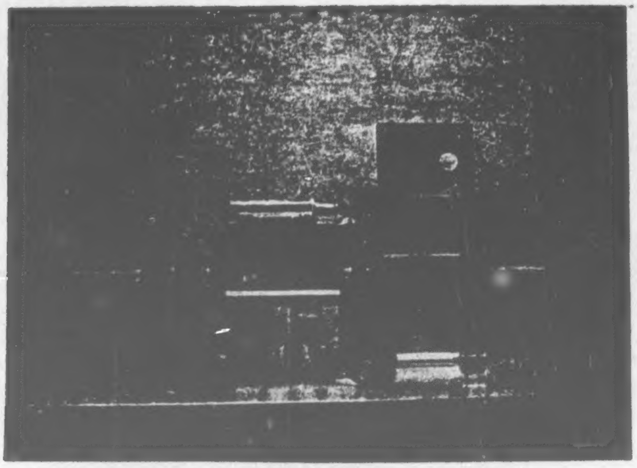


Figure 2. Ultrasonic Leak Detector.

Check the following statement/s that are true.

_____1. The ultrasonic leak detector is a completely transistorized unit.

_____2. It requires an external power source of 28 volts DC.

_____3. Audible sounds within the normal hearing range are picked up by the unit.

_____4. Sounds of ultrasonic frequency are converted to human hearing range.

_____5. The loudspeaker can still be heard with the headset plugged in.

2811

Answers to frame 2: 1. ✓ 2. ____ 3. ____ 4. ✓
5. ____

Frame 3

The MH-2 oxygen regulator tester accurately checks the regulator demand diaphragm, the air inlet check valve, and the mask-to-regulator hose for leaks. The pressure being applied and the degree of leakage occurring can also be correctly determined with this tester. Another use of this tester is to determine the amount of oxygen flow from the regulator in the EMERGENCY and TEST MASK positions. The tester has a pressure gage, flowmeter gage, rubber squeeze bulb, rubber bladder, and two adapters. The pressure gage indicates the pressure in inches of water applied to the regulator. The flowmeter indicates any regulator leakage in liters per minute. One connector is made of metal, and is used when attaching the tester to the mask-to-regulator hose. The rubber stop adapter is used when connecting into the outlet port of the regulator.

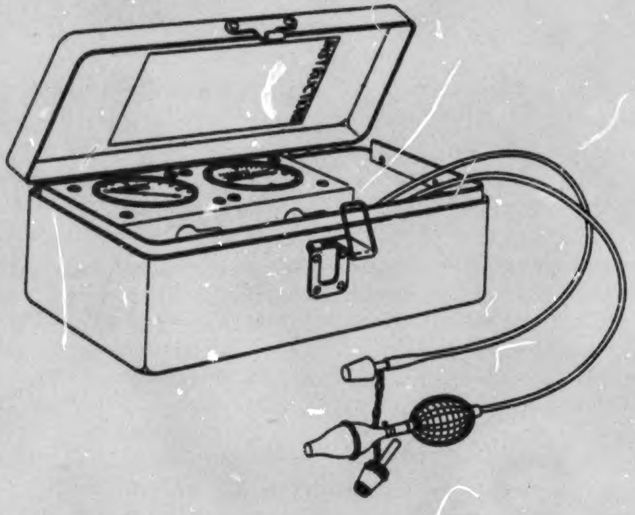


Figure 3.

Mark the following statements with a T for True or an F for False.

____1. The MH-2 tester is used to check the air inlet check valve, mask-to-regulator hose, and demand diaphragm for leaks.

____2. The pressure gage indicates in inches of water.

____3. The flowmeter indicates in psi.

____4. The tester is connected to the mask-to-regulator hose by using the rubber stop adapter.

Answers to frame 3: 1. T 2. T 3. F 4. F

Frame 4

There are different types of liquid oxygen servicing trailers in use throughout the Air Force. The example shown below is a Type TMU-27/M.

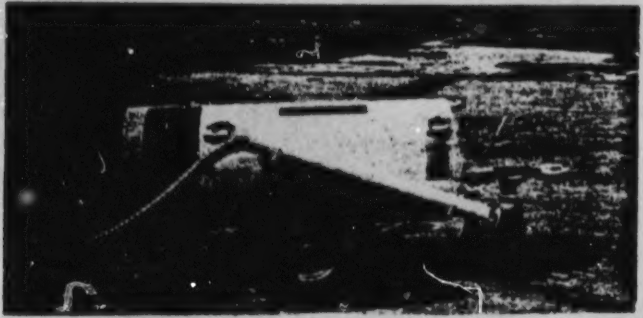


Figure 4. Type TMU-27/M Servicing Trailer.

Although the trailers may look completely different, they must adhere to certain basics. All carts consist of an inner and outer tank, and have an insulating material between the tanks. Also, the area between the tanks is evacuated of air, like a thermos bottle. All units have a capacity gage and a pressure gage. Safety features include tank and hose relief valves. These valves are of the automatic-manual or completely automatic type. The tank relief valve prevents an excessive buildup of pressure when the tank is pressurized. Excessive pressure may be caused by the operator failing to close the build-up valve at the desired pressure. The automatic-manual valve can be hand operated to relieve the pressure. The hose relief valve prevents rupture of the servicing hose. When the trailer servicing valve is closed, and the hose disconnected from a converter filler valve, trapped liquid in the hose turns to gas with an increase in pressure. Again, if the valve is the automatic-manual type, the operator can relieve the hose pressure. If the unit develops a leak in the inner tank, a means of pressure relief is provided to prevent rupture of the outer tank.

Check the following statement/s that are true.

_____1. Certain basics must be adhered to in the construction of trailers.

_____2. All have an inner and outer tank.

_____3. Air is pumped into the area between the tanks.

_____4. A means of pressure relief is provided if the inner tank leaks.

2813

Answers to frame 4: 1. ✓ 2. ✓ 3. ____ 4. ✓

Frame 5

The control section for operation of all mobile units is at the rear end of the unit. The control section shown below is from the Type TMU-27/M liquid oxygen servicing unit.

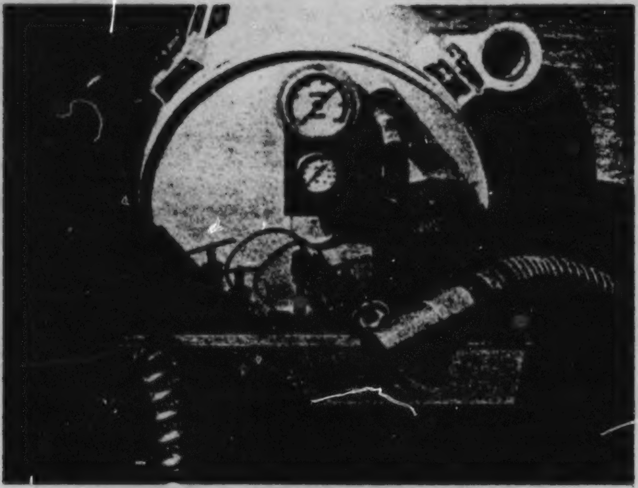


Figure 5. TMU-27/M Liquid Oxygen Servicing Trailer Control Section.

All trailers have three basic valves. The first is a vent valve. It is normally open and is closed only when the tank is to be pressurized to force the liquid out of the tank. The second is a buildup valve. It is normally closed and is opened when you desire to build up pressure in the tank. The third valve is referred to as a fill-drain valve on some tanks and a transfer valve on others. It is used to transfer liquid from the tank, through the transfer hose, and into the converter to be filled. If the valve is referred to as a fill-drain valve the tank is also filled through this valve. This is done by removing the servicing hose and attaching a larger hose that is connected to a storage tank of 500 gallons or more. If it is referred to as a transfer valve the tank has a separate fill point and an additional valve is installed.

The transfer hose is constructed of an inner and outer hose which have insulation between them. Hoses are steel wire wrapped, have an aluminum scuff guard, and a standardized servicing nozzle.

Mark the following statements with a T for True or an F for False.

_____ 1. Three basic valves are required on all units.

_____ 2. The vent valve is normally closed.

_____ 3. The buildup and fill-drain or transfer valves are normally closed.

_____ 4. All transfer hoses are steel wire wrapped.

_____ 5. The servicing nozzles are standardized.

2814

Answers to frame 5: 1. T 2. F 3. T 4. T 5. T

Frame 6

The type TTU-162/E liquid oxygen converter tester, shown below, is used in the shop for bench checking liquid oxygen converters. The vacuum space, build-up time, operation of the pressure closing valve, design flow, and the system relief valve opening pressure and reseating leakage can all be checked to determine operational suitability. Although Air Force type TTU-162/E converter testers may look different, they all have the same basic components.

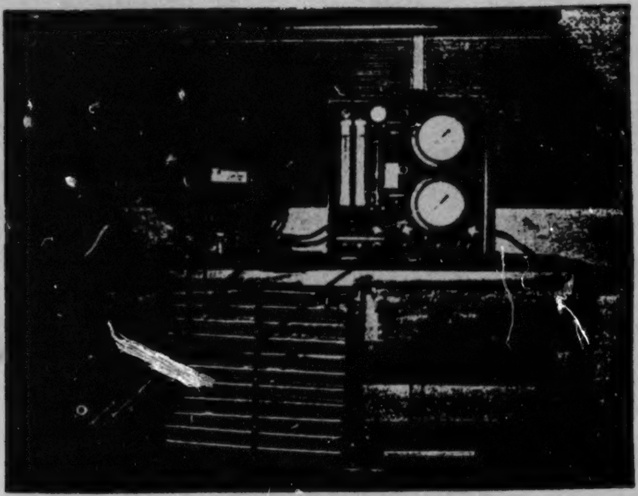


Figure 6. Type TTU-162/E Converter Tester.

No response required.

196

2815

Frame 7

Shown below is a typical TTU-162/E control panel. On the panel are three valves; the supply, buildup, and vent valves. At the right of the panel are the supply pressure and buildup pressure gages which indicate from 0 to 600 psi. Three flowmeters are provided. The evaporation loss flowmeter is used when checking the converter vacuum. The leakage flowmeter checks the system relief valve for proper reseating after opening. The large flowmeter with the temperature indicator above it is in use when checking a converter assembly for design flow. When the supply valve is open, gaseous oxygen flows through this unit and passes the temperature indicator as it flows overboard. Three connectors are provided for attaching the tester to the converter under test and the necessary evaporator coils. These connections may be standard or of the quick disconnect type. An exhaust vent, which is an outlet for liquid to spill from when filling the converter, is used as a test port when checking converter vacuum.

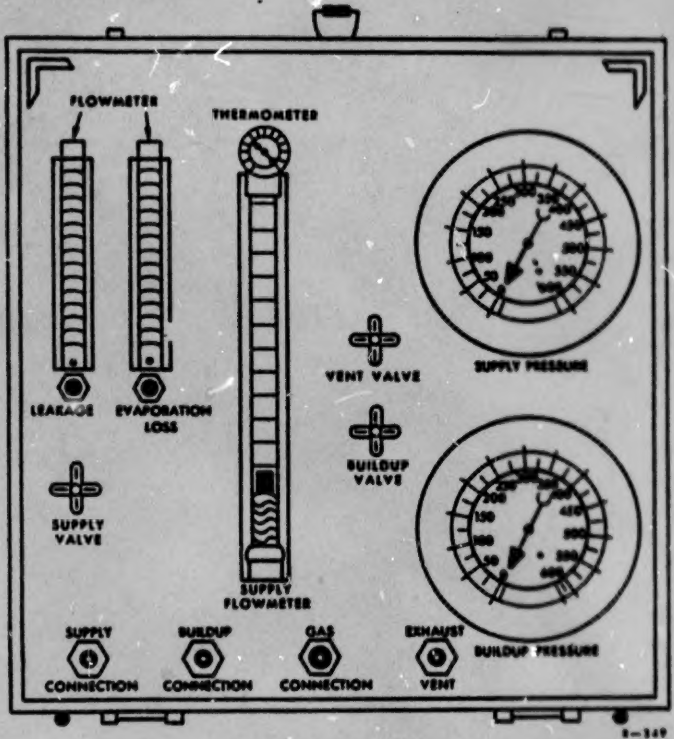

FLOWMETER
THERMOMETER
LEAKAGE
EVAPORATION LOSS
SUPPLY VALVE
SUPPLY FLOWMETER
VENT VALVE
BUILDUP VALVE
SUPPLY PRESSURE
BUILDUP PRESSURE
SUPPLY CONNECTION
BUILDUP CONNECTION
GAS CONNECTION
EXHAUST VENT
8-349

Figure 7. Liquid Oxygen Converter System Tester Type TTU-162/E.

Mark the following statements with a T for True or an F for False.

_____1. The three valves are titled supply, buildup, and vent.

_____2. To check the converter vacuum space the evaporation loss flowmeter is used.

_____3. Liquid oxygen flows through the supply flowmeter.

_____4. Liquid oxygen flows from the exhaust vent when a converter is filled.

Answers to frame 7: 1. T 2. T 3. F 4. T

Frame 8

The gaseous oxygen servicing cart, shown below, is the Air Force Type 02 unit which can handle two gaseous oxygen storage cylinders. It consists of a two wheeled hand cart, pressure regulator, oxygen purifier, and a servicing hose. At the end of the hose is a hand wheel type charging valve. The valve has a standard adapter that will connect to a gaseous oxygen filler valve. Two oxygen storage cylinders, which contain approximately 2200 psi when full, are connected by a common manifold to the pressure regulator.

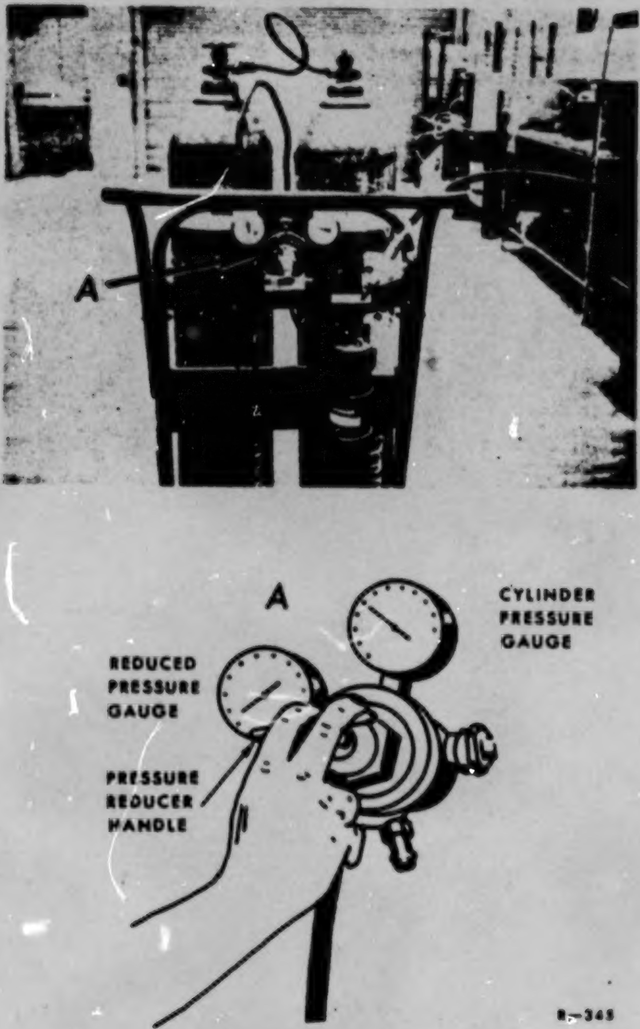

A
A
CYLINDER PRESSURE GAUGE
REDUCED PRESSURE GAUGE
PRESSURE REDUCER HANDLE
B-345

Figure 8.

No response required.

Frame 9

The first step in operation of the unit is to determine which cylinder has enough pressure for your immediate needs. The cylinder with the lowest usuable pressure is always used first. This is known as cascading. This is done by opening a storage cylinder valve. Oxygen enters the manifold at cylinder pressure up to the inlet side of the pressure regulator. The storage cylinder pressure is indicated on the cylinder pressure gage at this time. A pressure reading is taken and the valve is closed. The pressure reducer handle is turned in until about 10 psi is indicated on the reduced pressure gage. At this time the operator must open the charging valve until both pressure gages drop to zero to bleed the manifold and servicing hose. The operator must never point the charging valve at himself, other persons, walls or equipment because of the hazards involved in the use of compressed gases or air. The charging valve is reclosed and the pressure reducer handle backed out. The second cylinder is opened and a reading is taken of its pressure. The cylinder with the lowest usuable pressure is used first. The same procedure must be used whether using the O2 cart or larger units that have six or twelve mounted storage cylinders. Not more than one cylinder should be open at any time because the gaseous oxygen will flow from the cylinder of higher pressure into the one of lower pressure until the pressures equalize.

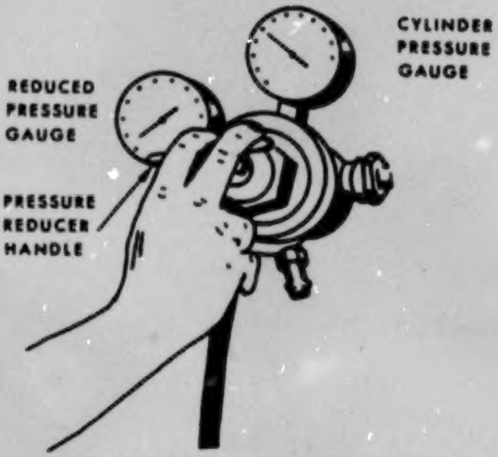


Figure 9.

Mark the following statements with a T for True or an F for False.

_____1. The first cylinder to be used must have the lowest usable pressure.

_____2. Only one cylinder must be opened at a time.

_____3. Pressures will not equalize if more than one cylinder is open.

2818

Answers to frame 9: 1. __T__ 2. __T__ 3. __F__

Frame 10

To reduce cylinder pressure, the pressure reducer handle is turned out slowly (counterclockwise). The pressure is indicated on the reduced pressure gage. Gaseous oxygen flows into the servicing hose at this reduced pressure. When the charging valve is opened, oxygen will flow into the unit being serviced. The flow continues until the reduced pressure set by the regulator, is reached. At this point, the regulator automatically stops the flow. If the unit being serviced is open to an overboard vent, oxygen will flow continuously at the reduced pressure.

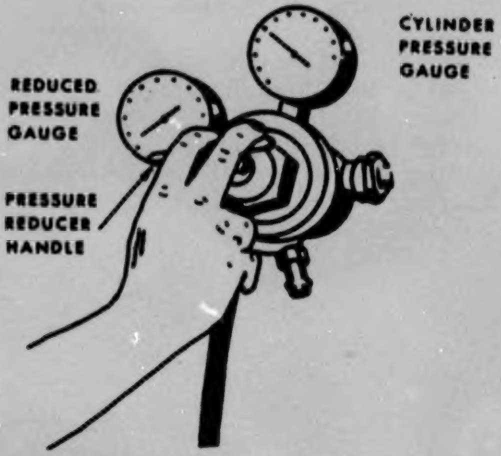


Figure 10.

Check the following statement/s that are true.

_____1. The pressure reducer handle is backed out to reduce pressure.

_____2. When the preset reduced pressure is reached the flow stops automatically.

2819

Answers to frame 10: 1. ✓ 2. ✓

Frame 11

Capacitance Type Liquid Quantity Systems Test Set Model TF-20-1 is a compact portable instrument which is used for testing and calibrating aircraft liquid oxygen converter probes, indicators and complete gauging systems. Tests can be performed with the gauging system installed in the aircraft, or with system components removed from the aircraft for bench tests in the laboratory, shop or field.

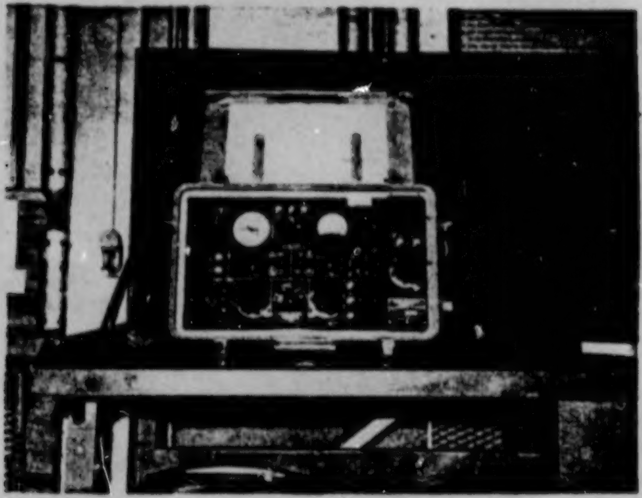


Figure 11. Capacitance Type Liquid Quantity Systems Tester Model TF-20-1.

No response required.

201

2820

Frame 12

The test set includes a waterproof case, adapter cables, and special adapter harness assemblies for different aircraft. Circuitry is provided for measuring capacitance, d-c electrical resistance, and for simulating the capacitance of compensated and uncompensated type tank probes. This tester operates from a power source of 115 volts at 400 cps. The front panel contains a capacitance indicator, megohmmeter, adapter cable connection points, and all operating controls. You will use the TF-20-1 Tester when doing Project No. 11 of your Lab workbook.

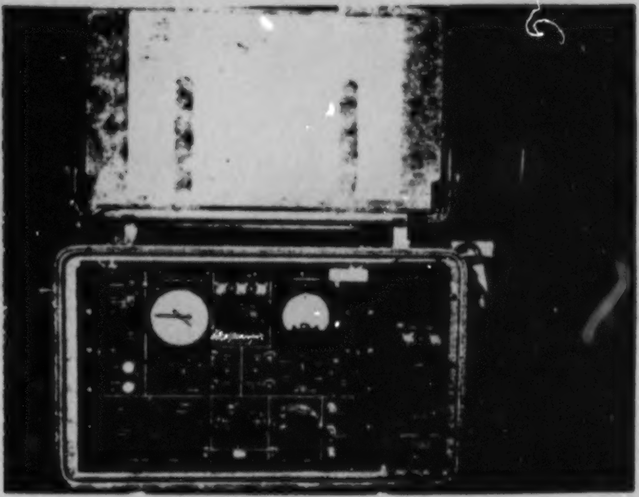


Figure 12.

Mark the following statements with a T for True or an F for False.

_____1. Only one type aircraft can be checked with the TF-20-1.

_____2. The test set operates on 115 volts 400 cps.

_____3. All controls for operation are on the front panel.

Answers to frame 12: 1. F 2. T 3. T

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Environmental Pneudraulic Branch
Chanute AFB Illinois 61868

3ABR42331-HO-402
30 June 1978

FOREIGN OBJECT DAMAGE PREVENTION AND COMPOSITE TOOL KITS (CTK)

Dollars out of your pocket!! Sounds drastic, doesn't it? Everyday throughout the military, thousands of dollars are wasted through foreign object damage (FOD). These initials - FOD - are probably new to you, but during your stay in the Air Force they will become familiar to you.

Foreign Object Damage is caused by a variety of things, mostly man-made. A mechanic installs a new engine bleed valve. During his installation he drops a ¼" bolt (sounds pretty small, right?). In his haste to complete the job he fails to check the area for FOD items. This small ¼" bolt is eaten by the engine. Engines, you will find, have a big appetite, they will eat anything that can pass their inlet: bolts, nuts, safety wire, tools, rocks, even ear defenders and hats. The bolt, while being digested by the engine, nicks two compressors and three turbine blades. This damage does not become known until the pilot advances the throttles on takeoff. The turbine blades crack, causing the engine to be out of balance. The engine disintegrates, rupturing the fuel cells. Scratch one aircraft, eight people (four crew members and a family of four) as the aircraft crashes on a highway two miles from the end of the runway. Although this is ficititious, incidents such as this have happened and will continue, unless we all practice good FOD prevention.

In dollars alone, we spend millions that need not be spent from damage caused by foreign objects. In 1976, SAC alone spent over a million dollars due to FOD. This includes damaged engines, tires, equipment and personal injuries.

We all complain about spending our money, especially when we have nothing to show for it. FOD is a major drain on your pocket. Being in the Air Force you tend to lose twice. How? First, your tax dollars must be used to remedy FOD, they must pay to replace or repair items damaged by FOD. Secondly, since the Defense budget is fixed (you get a set amount to operate on for one year), the more you spend which you do not need to, the less you have to operate on a daily basis. As an example of this: if a B-52 tire is damaged by FOD, $280.00 is spent out of the Air Force budget. This is $280.00 less you'll have to spend on new equipment to make your job a little easier. It is really a needless expense, so practice good FOD prevention, it makes good sense!

While doing your projects, you will be required to practice FOD prevention. This means you will use care not to allow nuts, bolts, safety wire, etc. to be left in your work area when you complete your assigned job. Use the magnet provided to remove all traces of FOD.

OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG - 600; TTVSA - 1

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

2822

Clean up your project area. If your instructor finds FOD items during his inspection of your project, you will be required to reaccomplish the project. This is treated the same as a technical error and a failure will be entered in your progress record. Get used to it now, since it will become a part of your everyday life during your Air Force career.

While you are doing your projects, you will also use a Consolidated Tool Kit (referred to as a CTK). The CTK program is one of many integral parts of the FOD program. This kit is a quick means of identifying lost or misplaced tools. They are made in many forms, such as bags, shadow boards, metal and wooden boxes. Some are even designed to fit into briefcases.

A CTK is one of these containers mentioned and is usually filled with strips of styrofoam or some type of spongy material. A silhouette of that tool is cut out and usually painted a specific color. The tools required to do the job are then placed in the container. This is done so that any shortage can instantly be identified.

If any shortage does occur, you can easily find the tool since you have not left the job. You must backtrack until you find the tool. This will prevent FOD and perhaps save thousands of dollars in FOD damage.

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WORKBOOK
3ABR42331-WB-403

Technical Training

Aircraft Environmental Systems Mechanic

OXYGEN SYSTEMS LABORATORY PROJECTS

20 November 1978

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

2824

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Supersedes 3ABR42231-WB-402, 15 September 1975.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370TCHTG/TTGU-P - 600; TTVSA - 1

2825

Environmental Pneudraulic Branch
Chanute AFB, Illinois

OXYGEN SYSTEMS OXYGEN LABORATORY PROJECTS

OBJECTIVES

The objectives for each project is given in the heading of the individual projects. Read the objectives to determine the task that is to be done and the equipment you will need.

EQUIPMENT

	Basis of Issue
Oxygen System Trainer Number 3251	1/student
Go-No-Go Gage	1/student
Test Gage, TTU-28/E	1/student
Leak Tester, MH-2	1/student
Sonic Leak Detector	1/student
Liquid Oxygen System Tester, TF-20-1	1/student
Tester Type TTU-162/E	1/student
Hot Purge Kit Heating Assembly	1/student
Oxygen System Trainer Number 1762	1/student
Tester Type MH-1	1/student
LOX Trailer, TMU-27/M	1/student
LOX Trailer, A-1	1/student
Pressure Demand Regulator, D2-A	1/student
Demand Regulator	1/student
TO 15X-1-1	1/student

INFORMATION

If you cannot find the equipment that is used with a project, call an instructor. Any test equipment used will be put back in the same manner that it was found.

One of the most important things the instructor will check you on is safety while you work in the oxygen laboratory. Do not take any chances with liquid oxygen (LOX) or with the electrical equipment. WORK SAFELY.

Read all instructions carefully. If in doubt, ask your instructor for help. Your instructor will move you to the work area for each project. You will use the list of equipment as directed by the various laboratory projects. Each project has a list of specific procedures.

SPECIAL SAFETY PRECAUTIONS

There will be no danger with any of the projects, if you follow instructions. An instructor will be available at all times to help you.

You will work with liquid oxygen (LOX). You must locate and observe all safety points that must be followed when handling LOX. To help you we have made a list of the safety points.

2826

1. Hazards of handling liquid and gaseous oxygen.

a. Liquid oxygen in contact with the skin will cause frostbite and burns.

b. When liquid oxygen is mixed with fuels it will cause a dangerous explosive hazard.

c. Frozen fuel/liquid oxygen mixtures are "shock sensitive."

d. When gaseous oxygen is absorbed in clothing it will stay for some time.

2. First aid procedures.

a. If liquid oxygen gets in the eyes, immediately flood the eyes with water. (See the instructor for the water location.)

b. If liquid oxygen gets on the bare skin, thaw the area by flooding with water.

c. Get medical treatment immediately if liquid oxygen gets on the skin or in the eyes.

3. Safety precautions.

a. Remove all your jewelry now.

b. There will be NO SMOKING in the oxygen laboratory at any time.

c. Personnel must wear the proper face shield, apron, and gloves when handling liquid oxygen. This equipment is provided in the laboratory for your use.

d. You must read sections in TO 15X-1-1 that give points on oxygen safety and oxygen servicing equipment. Ask your instructor for the page numbers and paragraphs you are to read.

PROJECT NUMBER 1: INSPECTS OXYGEN SYSTEM

OBJECTIVES

After completing this project, you will be able to:

1. Follow inspection work card instructions (AFTO Form 26) to inspect the condition of an oxygen system.

2. Use a GO-NO-GO gage and trainers to check the condition of the mask-to-regulator hose connectors.

Standard of Performance:

Your ability to reach the objectives of this project will be evaluated by an instructor, using a criterion reference checklist.

PROCEDURES

1. Check all the items on the inspection work card. When you reach step 9, obtain the GO-NO-GO gage from locker #1.

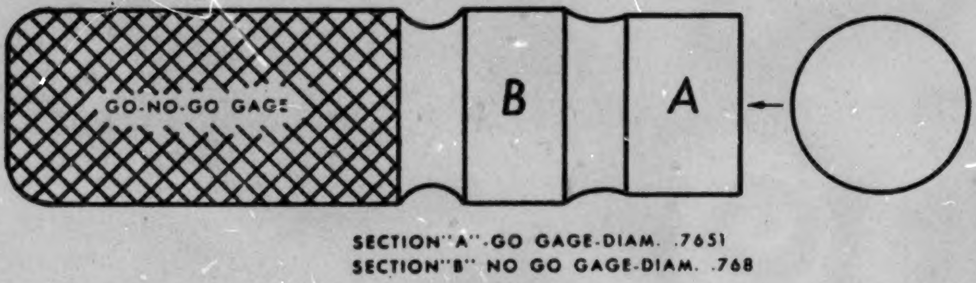
GO-NO-GO GAGE
B
A
SECTION "A"-GO GAGE-DIAM. .7651
SECTION "B" NO GO GAGE-DIAM. .768

Figure 1. GO-NO-GO Gage.

2. Use the GO-NO-GO gage to check the inside diameter of the female connector on the mask-to-regulator hose on trainers in the lab. Have the instructor check your work. Identify worn connectors to the instructor.

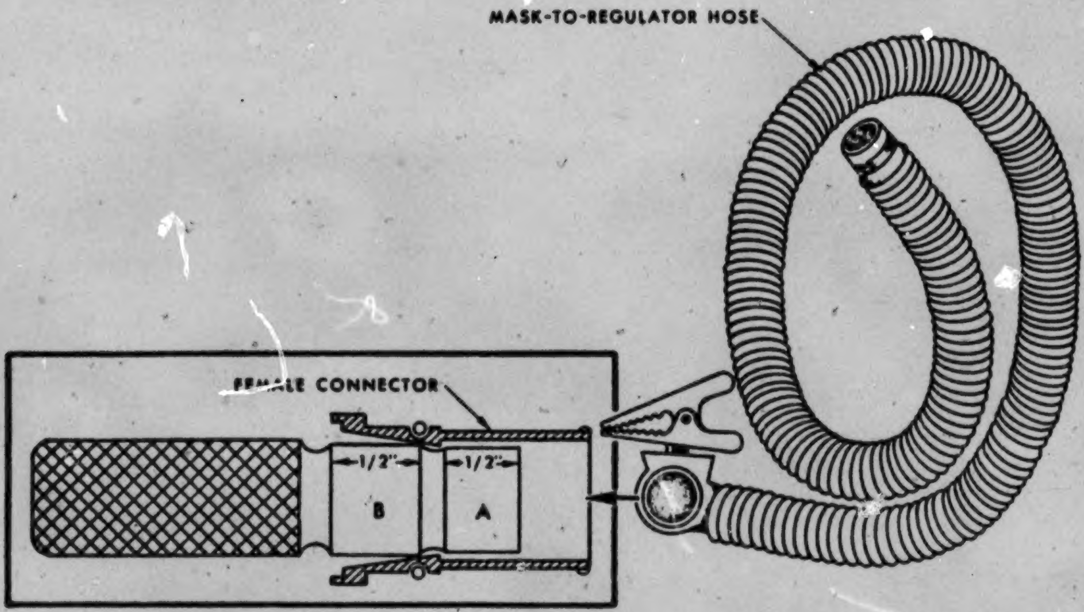
MASK-TO-REGULATOR HOSE
FEMALE CONNECTOR
1/2"
1/2"
B
A

Figure 2. Using the GO-NO-GO Gage.

Note: As shown in figures 1 and 2, "A" of the gage is the "GO" (small diameter) part and "B" is the "NO-GO" (large diameter) part.

3. Put the gage in the female connector of the mask-to-regulator hose, as shown in figure 2. Push the gage straight in, but do not force it. A slight rocking or twisting motion may be used.

4. The "GO" part of the gage (A) is small and should slip through the smallest internal diameter of the connector. The "NO-GO" part (B) should not go through the small part of the connector. If it does, the connector has too much wear and must be replaced.

PROJECT NUMBER 2: PURGING LIQUID OXYGEN SYSTEM (COLD PURGE)

OBJECTIVES

After completing this project, you will be able to:

1. Use the master oxygen test gage TTU-28/E to purge (clean) a liquid oxygen system.

2. Transfer gaseous oxygen from a gaseous oxygen storage cylinder, through a liquid oxygen system trainer to a liquid oxygen system.

3. Use the liquid oxygen system trainer to purge a liquid oxygen system.

4. Check the pressure of a gaseous oxygen storage cylinder.

Standard of Performance:

Your ability to reach the objectives of this project will be evaluated by an instructor.

PROCEDURES

1. Prepare the trainer.

a. Check the liquid quantity gage. The system must be empty. If the system is not empty, the liquid oxygen converter will have to be drained. When you work on an aircraft, check the technical order for the proper procedures.

b. Place the oxygen regulator supply switch to ON and the emergency switch to EMERGENCY. This is for the D-2A regulator.

Note: To purge a system on the flight line, first vent the mask-to-regulator hose or hoses to the outside of the aircraft. This can be done through an open canopy, hatch, or entrance way. This will stop the buildup of an oxygen rich atmosphere. An oxygen rich atmosphere is very dangerous.

c. Place the buildup and vent valve to the vent position. Take the handle from the clip and the dust cap from the oxygen filler valve.

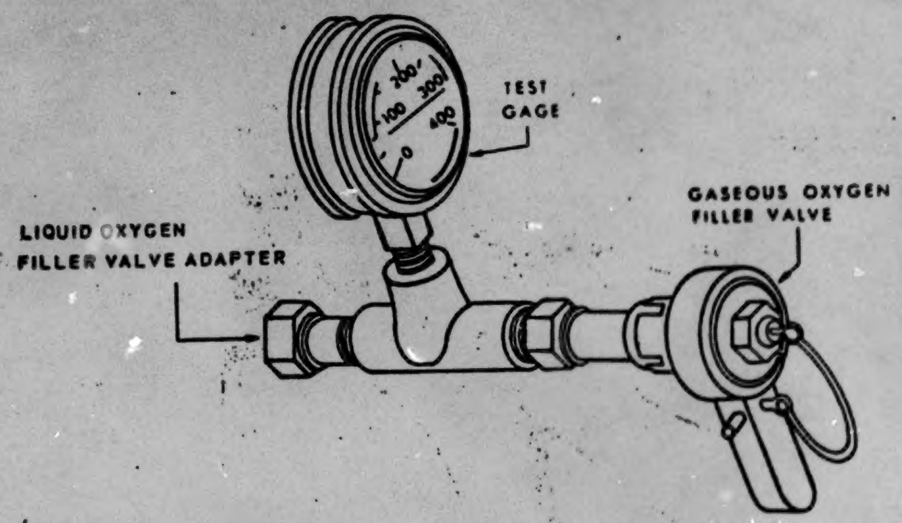
TEST GAGE
0
100
200
300
400
GASEOUS OXYGEN FILLER VALVE
LIQUID OXYGEN FILLER VALVE ADAPTER

Figure 3. Master Oxygen Test Gage TTU-28/E.

d. Connect the TTU-28/E master test gage to the trainer. Screw the liquid oxygen filler valve adapter of the gage (figure 3) on the threaded part of the liquid oxygen filler valve.

> Note: On some aircraft, the buildup and vent valve handle would have to be removed to place the system in the buildup position, with the master gage connected. However, on the trainer it is not necessary.

2. Prepare the Gaseous Oxygen Servicing Unit (see figure 4).

a. Check to be sure that the pressure reducer handle is backed out (turn counterclockwise (CCW) and is free to turn (figure 4)).

b. Slowly open the oxygen cylinder valve and watch the oxygen high pressure gage (figure 4). If you have an oxygen cylinder with a pressure of less than 400 psi, ask your instructor for more instructions before continuing.

> Note: Do not drain cylinders below 50 psi. A charge of 50 psi or more in the cylinders will stop the accumulation of moisture in the cylinders.

c. Slowly turn (clockwise (CW) the pressure reducer handle (figure 4)) until the reduced pressure gage reads 50 psi.

d. Open (CCW) the charging valve handle (figure 4) on the supply hose. Purge the hose for ten (10) seconds. Close (CW) the charging valve. BE SURE TO POINT THE NOZZLE AWAY FROM YOURSELF, OTHERS, AND WALLS.

> Note: Purging removes any contaminants (dirt or moisture) that may be inside the hose.

2830

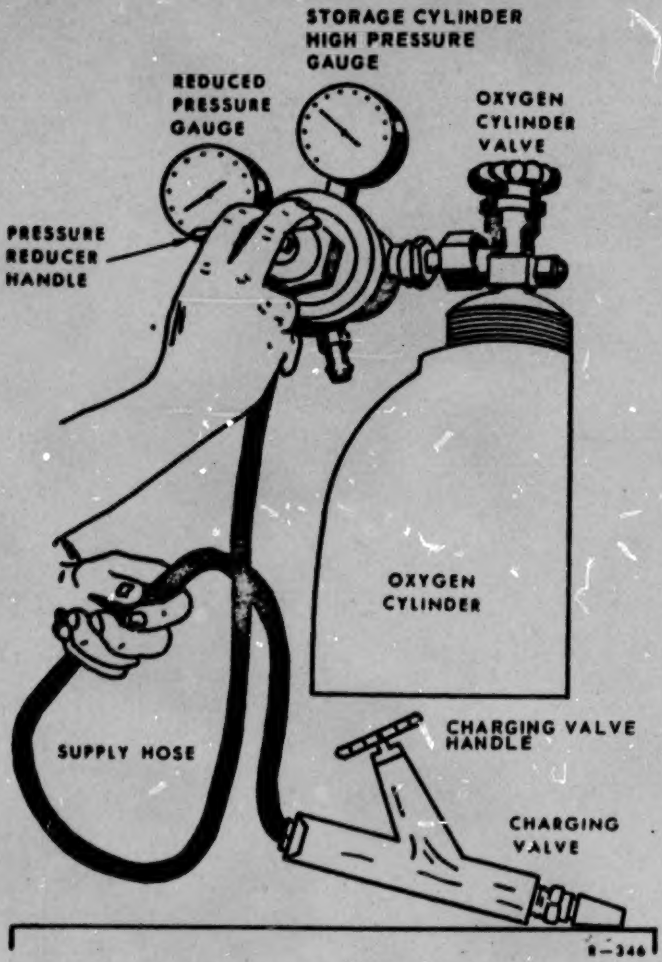
STORAGE CYLINDER
HIGH PRESSURE
GAUGE
REDUCED
PRESSURE
GAUGE
OXYGEN
CYLINDER
VALVE
PRESSURE
REDUCER
HANDLE
OXYGEN
CYLINDER
CHARGING VALVE
HANDLE
SUPPLY HOSE
CHARGING
VALVE
8-346

Figure 4. Gaseous Oxygen Servicing Unit.

e. Connect the charging valve to the gaseous oxygen filler valve (figure 3) on the master test gage. The gaseous oxygen filler valve is a quick disconnect unit. The adapter on the charging valve will lock automatically.

3. Purging the system.

a. Place the oxygen regulator supply switch ON.

b. Open the charging valve on the supply hose.

c. Readjust the pressure reducer handle to keep a flow of oxygen to the TTU-28/E test gage at 50 psi.

d. Allow oxygen to flow through the system for 5 minutes.

Note: In the field use the purge time and steps that are in the technical order for the aircraft on which you are working.

2831

e. Close the charging valve on the supply hose.

f. Place the oxygen regulator supply switch OFF.

g. Place the regulator emergency switch to the NORMAL position.

h. Back out the pressure reducer handle on the servicing unit.

Note: The system is now purged. In the field the aircraft should be serviced with LOX within two hours after it has been purged.

i. This ends the project on cold purging. Leave the trainer and servicing unit as is and start on the next project.

PROJECT NUMBER 3: LIQUID OXYGEN SYSTEM PRESSURE LEAK TEST

OBJECTIVES

After completing this project, you will be able to:

1. Use the master oxygen test gage TTU-28/E to make a pressure leakage test.

2. Transfer gaseous oxygen from a gaseous oxygen storage cylinder to a liquid oxygen system trainer.

3. Make a pressure leakage test on a liquid oxygen system trainer.

4. Check the pressure of an oxygen storage cylinder.

Standard of Performance:

Your ability to reach the objectives of this project will be evaluated by an instructor, using a criterion reference checklist.

PROCEDURES

1. Be sure that the TTU-28/E test gage and servicing hose are still connected to the trainer.

2. Place the buildup and vent valve handle to the BUILDUP position.

3. Turn the oxygen regulator supply switch to the OFF position.

4. Open the charging valve on the supply hose.

5. Slowly turn IN the pressure reducing handle on the servicing unit. Charge the system to 300 psi. Use the TTU-28/E test gage to check the pressure.

6. Close the charging valve on the gaseous oxygen supply hose. Disconnect the charging valve from the test gage.

7. The pressure shown on the TTU-28/E test gage is ______ psi.

8. Close the oxygen cylinder valve and back OUT the pressure reducing handle. Open the charging valve and bleed the pressure from the manifold and charging hose. Be sure to point the nozzle away from yourself, others and walls.

9. Let the system stand for 15 minutes. (30 minutes is normal time for an aircraft system.)

10. The pressure in the system now is _____ psi. Subtract this reading from the first reading. The difference is _____ psi.

MAXIMUM ALLOWABLE PRESSURE LOSS FOR THE 15 MINUTE TEST

5 liter converters	6.0 psi drop
8 liter converters	3.5 psi drop
10 liter converters	2.5 psi drop
20 liter converters	2.0 psi drop
25 liter converters	1.5 psi drop
75 liter converters	none is allowed

11. If leakage is more than the listed value, the leaks will have to be found, and identified to your instructor.

12. This ends this project. Leave the trainer as is and start the next project.

PROJECT NUMBER 4: LOCATING OXYGEN SYSTEM LEAKS

OBJECTIVES

After you have done this project, you will be able to:

1. Use an ultrasonic leak detector to check for oxygen system leaks.
2. Use the LEAK TEC solution to check for oxygen system leaks.
3. Explain the operation of the ultrasonic leak detector.
4. Explain the use of the LEAK TEC solution to check for oxygen system leaks.

Standard of Performance:

Your ability to reach the objectives of this project will be evaluated by an instructor, using a criterion reference checklist.

PROCEDURES

1. Use of the Ultrasonic Leak Detector.

Note: Refer to figure 5 as you get the detector ready for use.

a. Take the probe assembly from the top of the carrying case and the lead assembly from inside the cover of the case.

b. Plug the lead into the probe assembly.

c. Plug the other end of the lead into the jack marked PROBE.

d. Place the switch to the ON position.

e. Turn the volume control to the right to get more volume.

f. Blow into the PROBE to check for sound output. Readjust the volume control if necessary.

g. Slowly move the probe over the tubing and all fittings to check for leaks. A leak will cause the unit to make a sound. As the probe is moved close to a leak the sound will get louder.

h. Have an instructor check your work.

i. Turn the tester switch to the OFF position.

j. If no leaks are found, put the lead assembly back in the carrying case cover, put the probe on top of the case.

2. Use of LEAK TEC (Soap) Solution.

a. Shake the bottle of LEAK TEC solution well to form small bubbles.

b. Put the solution on the fittings connecting the plumbing and components of the oxygen system trainer.

c. If there is a leak, the LEAK TEC solution will form more bubbles.

d. Be sure to wipe off any excess LEAK TEC solution from the trainer.

e. This ends this project on locating oxygen system leaks. Leave the trainer and servicing unit as is and start on the next project.

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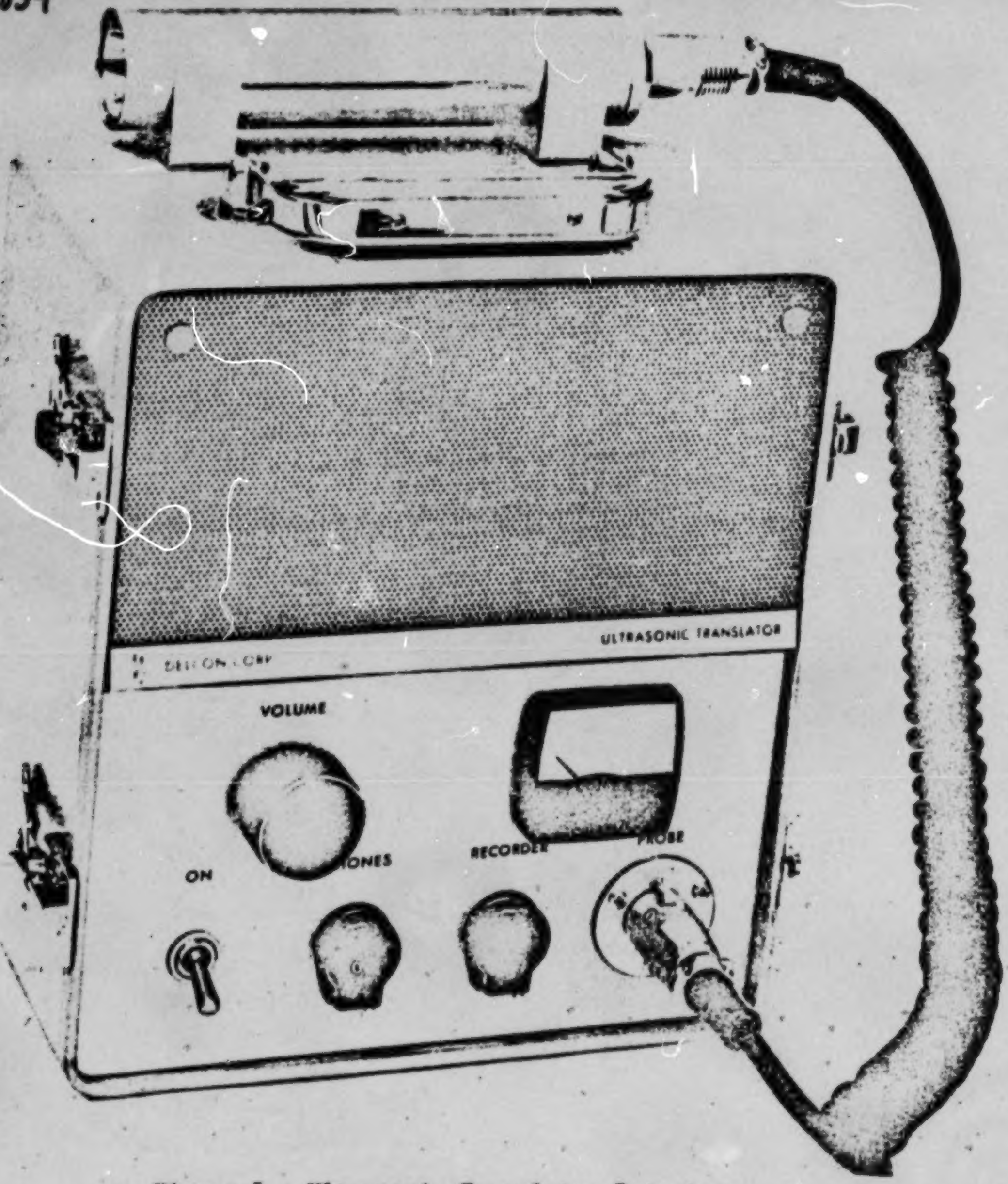
ULTRASONIC TRANSLATOR
DELCON CORP
VOLUME
ON
PHONES
RECORDER
PROBE

Figure 5. Ultrasonic Translator Detector.

PROJECT NUMBER 5: PERFORMING A REGULATOR DEMAND VALVE LEAK TEST WITH THE MH-1 TESTER

OBJECTIVES

After completing this project you will be able to use the MH-1 demand valve leak tester, a soap solution and an oxygen trainer to make a regulator demand valve leak test.

Standard of Performance:

Your ability to reach the objective of this project will be evaluated by an instructor, using a criterion reference checklist.

PROCEDURES

1. Plug end "A" of the MH-1 tester (figure 6) into the female connector of the mask-to-regulator hose.

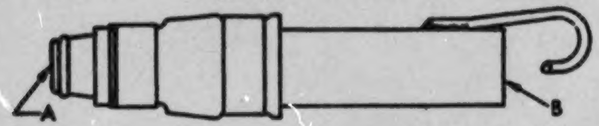

Figure 6. MH-1 Demand Valve Leak Tester.

2. Place the regulator emergency switch to the NORMAL position.

3. Place the supply switch to the OFF position.

4. Shake the bottle of soap solution well.

5. Squeeze some of the solution onto your finger.

6. Apply the solution across end "B" of the MH-1 tester (figure 6) to form a film of soap.

7. If a bubble forms from the "B" port and breaks on the pointed hook in less than 8 seconds, the demand valve leaks too much. If the bubble stays under the pointed hook for more than 8 seconds, the leakage is within tolerance. The regulator must be changed if it leaks too much.

8. This ends the demand valve leak test. Start the next project.

PROJECT NUMBER 6: OPERATIONAL CHECK OF AN OXYGEN REGULATOR

OBJECTIVE

After completing this project, you will be able to use an oxygen mask and an oxygen system trainer to make an operational check of an oxygen system.

Standard of Performance:

Your ability to reach the objective of this project will be evaluated by an instructor, using a criterion reference checklist.

PROCEDURES

1. Connect the oxygen mask to the mask to regulator hose.

2. Place the oxygen regulator supply switch to the ON position, the diluter switch to the NORMAL position and the emergency switch to the NORMAL position.

3. Breathe normally through the mask and watch the flow indicator on the oxygen regulator for operation. Now place the diluter switch to the 100% position and repeat this step.

4. Place the emergency switch to the EMERGENCY position. More oxygen should flow.

5. Put the emergency switch to the TEST MASK position. Much more oxygen should flow. Notice that by firmly holding the mask against your face, you will cause the flow blinker to go out.

6. This ends the operational check. Return the diluter switch to the NORMAL position, the supply switch to the OFF position and the emergency switch to the NORMAL position. Take the oxygen mask off the hose and put the mask back in the locker.

7. Secure the gaseous oxygen servicing unit.

   a. Close the valve on the oxygen storage cylinder.

   b. Open the charging valve on the supply hose until both of the pressure gages on the servicing unit read zero (0).

   c. Back out (CCW) the pressure reducing handle.

   d. Close the charging valve.

   e. Recheck the gages to be sure they both read zero (0).

   f. If the gages are not at zero (0), repeat steps a through d.

8. Secure the oxygen system trainer.

   a. SLOWLY move the buildup and vent valve handle to the VENT position.

   Note: After the system has been drained, pressure will be trapped in the system and will show on the pressure gage. This is normal. DO NOT bleed off this pressure.

   b. Disconnect the TTU-28/E master test gage.

   c. Put the dust cap on the filler valve, and on the master test gage.

   d. Place the handle in the clip.

   e. Reposition the build-up and vent handle to "build-up."

9. This ends the project, start on the next project.

PROJECT NUMBER 7: USING THE OXYGEN REGULATOR LEAKAGE TESTER MH-2

OBJECTIVE

After completing this project, you will be able to use the oxygen regulator leakage tester (type MH-2) and a trainer to check an oxygen regulator demand diaphragm and the mask-to-regulator hose for leaks.

Standard of Performance:

Your ability to reach the objective of this project will be evaluated by an instructor, using a criterion reference checklist.

Note: Before testing the regulator for leakage, the tester has to be checked for leaks. If a tester with a leak is used, the regulator leakage reading will be wrong. To check the tester, put your finger over the end of the adapter hose. Pump up 17 inches of water pressure with the pressure bulb. Check for leakage on the flowmeter. NO leakage is allowed. Drop pressure by removing your finger from the end of the adapter hose.

1. Mask-to-Regulator Hose and Oxygen Regulator Leakage Test.

a. Check the oxygen regulator to be sure that each switch is positioned for the test.

(1)	Supply	"OFF"
(2)	Diluter	"NORMAL"
(3)	Emergency	"NORMAL"

b. Attach the metal adapter to the hose of the tester and put the adapter into the open end of the mask-to-regulator hose.

c. Close the bleed screw (some units do not have a bleed screw) that is between the bag and pressure bulb.

d. Squeeze the pressure bulb several times until the tester pressure gage shows 17 inches of water pressure.

e. Hold this pressure by squeezing the bag.

f. Leakage should not be more than 1.0 liter per minute.

g. Place the diluter switch to the 100% position.

h. Squeeze the pressure bulb several times until the pressure gage shows 17 inches of water pressure.

i. Leakage should not be more than 0.5 liter per minute.

Note: If 17 inches of water pressure can not be reached in either the NORMAL or 100% positions, there is a leak. The leak could be in either the mask-to-regulator hose or the regulator demand diaphragm. To find which unit has the leak, do steps (1) through (5).

(1) Take the metal adapter from the mask-to-regulator hose.

(2) Take the mask-to-regulator hose from the regulator.

(3) Take the metal adapter from the tester hose.

(4) Put the rubber adapter on the tester hose and plug the tester hose into the regulator outlet port.

(5) Do steps c through i again.

k. If there are no leaks, the oxygen regulator demand diaphragm is good. The leak is in the mask-to-regulator hose.

Note: After the leakage test is done the MH-2 tester could be connected to the units in one of two ways.

(1) If there is no leak in the mask-to-regulator hose, the METAL ADAPTER should still be attached to the hose. Check to make sure the adapter is still attached.

(2) If there was a leak in the mask-to-regulator hose, the RUBBER ADAPTER should be attached to the oxygen regulator outlet. Check to make sure it is installed.

The regulator pressure outlet test can be made with the MH-2 tester connected in either of the two positions.

2. Regulator Pressure Output Test.

Note: For this check, the D2-A oxygen regulator should show a minimum of 80 psi.

a. Crack the bleed screw on the tester to cause a slight leak. If there is no bleed screw, move the adapter on the hose to cause a slight leak.

b. Place the supply switch to the ON position.

c. Place the emergency switch to the EMERGENCY position.

d. The pressure gage on the tester should now show a pressure of at least 2.75 inches of water. This is the correct output pressure.

e. Place the emergency switch to the TEST OR TEST MASK position and hold the switch in that position.

f. The pressure gage should show a pressure of from 6 to 17 inches of water for the test or test mask position to be good.

g. Place the supply switch to the OFF position.

h. Place the test or test mask switch to the NORMAL position.

i. Take the tester from the oxygen system trainer and store all parts in the tester box.

j. This ends the MH-2 test project.

PROJECT NUMBER 8: PURGING THE LIQUID OXYGEN SYSTEM (HOT PURGE)

OBJECTIVES

After completing this project, you will be able to:

1. Use the hot purge kit to purge an oxygen system.

2. Transfer gaseous oxygen from a gaseous oxygen storage cylinder to the liquid oxygen system trainer.

3. Use the liquid oxygen system trainer to purge a liquid oxygen system.

4. Check the pressure of an oxygen storage cylinder.

Standard of Performance:

Your ability to reach the objectives of this project will be evaluated by an instructor, using a criterion reference checklist.

PROCEDURES

Note: The hot purge kit can be used to purge any liquid oxygen system. The kit can be used to remove moisture from the capacitance probe used with some liquid oxygen converters. Moisture on a probe can cause a wrong signal to be sent to the quantity indicator.

1. Prepare the trainer.

   a. The hot purge kit is in locker #2.

   b. Move the regulator supply switch to the ON position and the emergency switch to the EMERGENCY position.

   c. Vent the mask-to-regulator hose to the side of the trainer. This will drain the remaining system pressure that was left from project #6.

   d. Place the buildup and vent valve to the BUILDUP position.

   e. Take the dust cap from the filler valve.

   f. Take the dust cap from the filler nozzle end of the hot purge kit.

   g. Align the three studs (in the open end of the nozzle) with the three grooves on the filler valve on the trainer. (On some aircraft the buildup and vent valve handle will have to be removed for this test.)

   h. Push on the nozzle and twist it to the right to lock on the filler valve. Be sure the nozzle is fixed to the valve. Have an instructor check your work before proceeding.

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2. Prepare the Gaseous Oxygen Servicing Unit.

a. Check to see that the pressure reducer handle is backed out (CCW) and is free to turn.

b. Slowly turn IN the pressure reducer handle until the reduced pressure gage reads 50 psi.

c. Open the charging valve on the supply hose and purge the hose for 10 seconds, then close the valve.

d. Plug the charging valve into the gaseous oxygen filler valve, on the side of the hot purge kit.

e. Connect the electrical lead from the hot purge kit into a 110V AC, 60 Hz outlet.

3. Purging the System.

a. Open the charging valve on the gaseous oxygen supply hose.

b. Check the reduced pressure gage to be sure that oxygen under 50 psi is flowing into the hot purge kit. If not, turn the pressure reducer handle to adjust the pressure to 50 psi. (Oxygen should flow out the distribution hose from the regulator.)

c. Place the electrical switch, on the end of the hot purge kit, to the ON position. A red light should come ON. This shows that the kit is heating the gaseous oxygen that flows to the system. This light will cycle ON and OFF as the correct temperature is maintained.

d. Oxygen should flow through the system for 5 minutes. Aircraft purging time is listed in the aircraft TOs.

4. Disconnecting the Hot Purge Kit.

a. Place the electrical switch to the OFF position.

b. Close the charging valve on the oxygen supply hose.

c. Place the oxygen regulator supply switch to the OFF position.

d. Place the emergency switch to the NORMAL position.

e. Take the electrical lead from the wall outlet.

Caution: When disconnecting the charging valve from the hot purge kit, lift the kit only by the carrying handle and the insulated portion of the nozzle. This method will prevent burning your hands.

f. Take the charging valve from the hot purge kit.

g. Take the hot purge kit from the trainer filler valve and place it back in the carrying case.

h. Put the dust cap on the tester connection.

i. Put the dust cap on the trainer filler valve and place the buildup and vent valve to the vent position.

5. Secure the Gaseous Oxygen Servicing Unit.

a. Close the valve on the gaseous oxygen storage cylinder.

b. Open the charging valve on the supply hose until both pressure gages read zero (0).

c. Close the charging valve.

d. Recheck the gages to be sure they both read zero (0).

e. If pressure still shows on the gages, do steps a through c.

f. The system has been purged with the hot purge kit and should be serviced with liquid oxygen within 2 hours to prevent recontamination.

g. This ends this project.

Note: Check with your instructor before continuing.

PROJECT NUMBER 9: LIQUID OXYGEN SERVICING TRAILER

OBJECTIVES

After completing this project, you will be able to:

1. Connect a liquid oxygen converter to a liquid oxygen servicing cart (trailer).

2. Transfer liquid oxygen from the trailer into the converter.

3. Use safety precautions while handling liquid oxygen.

Standard of Performance:

Your ability to reach the objectives will be evaluated by an instructor.

PROCEDURES

> Note: This project is to familiarize you with the operation of a liquid oxygen servicing trailer. In the field you will service converters with oxygen. You can then use the TTU-162/E converter tester (figure 7) to bench check a converter in the shop.

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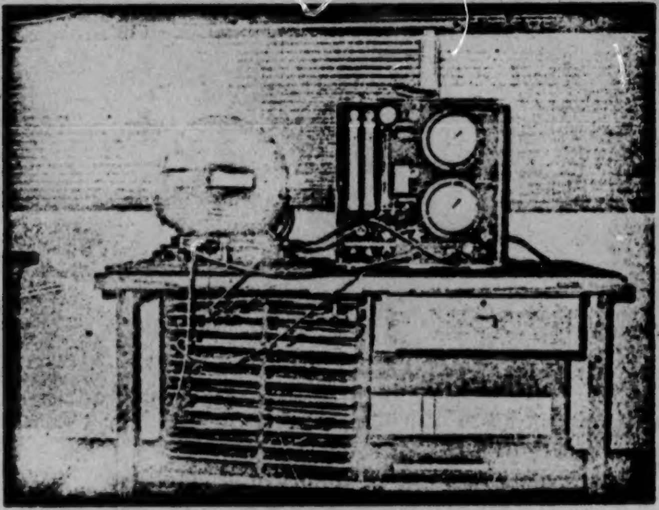

Figure 7. Converter and Test Equipment Hookup.

1. The converter (figure 7) you will be servicing is connected to a piece of test equipment and a coil of tubing. This is the TTU-162/E converter tester you will use in the next project.

2. The valves on the tester must be in the following positions before servicing the converter with LOX.

a.	Supply valve	CLOSED
b.	Buildup valve	CLOSED
c.	Vent valve	OPEN

3. Place a clean container under the piece of tubing attached to the tester exhaust vent. When the converter is full, liquid will come out of this vent.

Caution: Put on safety equipment -- gloves, face shield, and apron.

4. The instructor will give you the information you need to operate the servicing trailer. Read through the servicing checklist to find all the valves and parts before you start to service the converter. Follow the TO checklist as you do the servicing operation. If you have any problems, immediately call for an instructor to help you. After the converter is filled, go back to this workbook for further instructions.

5. After the converter is full, leave the trainer and tester in the positions they are in. Wait at least 15 minutes for the system to stabilize, then do the next project.

PROJECT 10: USING THE TTU-162/E LIQUID OXYGEN CONVERTER TESTER

OBJECTIVES

After completing this project, you will be able to:

1. Use the TTU-162/E converter tester to test a liquid oxygen converter.

2. Operate a TTU-162/E converter tester.

Standard of Performance:

Your ability to reach the objectives will be evaluated by an instructor, using a criterion reference checklist.

1. TEST NUMBER 1 - The vacuum space of the liquid oxygen converter under test needs to be checked for the loss of vacuum. A loss of vacuum will cause a high evaporation rate of the liquid.

a. Check to see that the vent valve is still OPEN.

b. Take the metal tubing and hose from the exhaust vent of the tester and place them on the bench.

c. Connect one end of the hose to the EVAPORATION LOSS FLOWMETER and the loose end of the hose to the EXHAUST VENT of the tester.

d. Watch the ball in the flowmeter. If the ball rises from zero (0), the amount of leakage is as shown on the markings of the glass tube. The leakage is ________ liters per minute.

e. Use the information in table 1 to choose the leakage that is allowed for the converter under test.

MAXIMUM LOSS SHALL NOT EXCEED	
Converter Size (Liters)	Allowable Leakage (Liters Per Minute)
5	0.60
8	0.69
10	0.75
20	0.92
25	1.0
75	2.1

Table 1. Allowable Converter Leakage.

f. Compare the leakage listed in step d with the leakage allowed for the converter under test. The converter vacuum is

(good/bad) __________.

g. Take the hose from the flowmeter and exhaust vent and place the hose on the bench. Do test number 2.

2. TEST NUMBER 2 - This test is made to find out how much time it takes the converter under test to buildup to operating pressure. Operation of the pressure closing valve will also be checked.

a. Close the vent valve on the tester.

b. Open the buildup valve.

c. Maximum buildup time to operating pressure (70 or 300 psi)

is 10 minutes. Record the start time ______________.

d. Watch the buildup and supply pressure gages. Both gages should rise at about the same rate.

e. At the end of 10 minutes look at the buildup gage. The pressure should be either 70 or 300 psi. Record the pressure.

_______ psi.

Note: If the converter does not reach operating pressure in 10 minutes, the pressure setting is out of tolerance (above or below 70 to 300 spi), the pressure closing valve must be adjusted or replaced.

f. The pressure closing valve is (good/bad) _______.

3. TEST NUMBER 3 - The converter under test will be checked for maximum and minimum pressures and flow rates. Liquid oxygen converters are made to give a set amount of gaseous oxygen per minute. The amount will change with the type of converter. During this test, the liquid oxygen that flows into the evaporator coils is changed to a gas that flows overboard through the supply flowmeter.

a. List the temperature that is shown on the temperature gage at the top of the supply flowmeter on the tester. The temperature is __________.

b. For the converter under test, find the design flow rate in table 2.

c. Watch the float in the supply flowmeter.

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CONVERTER	SPECIFICATION	NO. OF RELIEF VALVES	OP PRESS (PSI)	SIZE (L)	DESIGN FLOW (L/M)
A-2	MIL-C-6650	2	300	8	80
A-3	MIL-C-7407	2 (INDIVIDUAL)	70	5	20
MA-1	MIL-C-25021	2	300	20	120
ME-3	MIL-C-25674	2	300	25	150
GCU-2/A	MIL-C-25777	1	70	10	72
GCU-3/A	MIL-C-25781	1	70	10	72
GCU-10/A	MIL-C-25974	2 (INDIVIDUAL)	300	10	80
GCU-11/A	MIL-C-25972	2	300	10	100
GCU-12/A	MIL-C-25973	1	70	5	72
GCU-14/A	MIL-C-26358	1	70	5	72
GCU-17/A	MIL-C-27336	2	300	25	150
*GCU-20/A	MIL-C-27652	2	300	75	400

Table 2. Converter Data.

d. After the supply valve is opened, stabilize the top of the float at the design flow rate for the converter under test. This is done by opening and closing the supply valve and checking table 2.

e. Let oxygen flow for 15 minutes.

Caution: The evaporator coils and connecting plumbing will ice up during this test. Practice all safety precautions.

f. Watch the pressure gages. The pressure for the converter being tested is listed on the data plate for the converter. If pressure is not in the range set for the converter, the pressure closing valve is not working.

g. The minimum pressure is _____ psi. The maximum pressure is _____ psi.

h. Check the temperature gage. The temperature should be about the same as in step a.

Note: During the 15 minute oxygen flow test, read TEST NUMBER 4.

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4. TEST NUMBER 4 - This test is to check the system relief valve for proper opening and closing. During the flow test, liquid goes in the coils of the evaporator. A sudden stop in the flow of gaseous oxygen overboard, will cause the trapped liquid to turn to a gas. This will cause a high supply pressure. To protect the system the pressure relief valve must open at a set pressure.

Caution: During this test, stand clear of the converter relief valve vent.

a. Suddenly close the supply valve.

b. Watch the supply pressure gage and list the pressure at which the relief valve opens. The relief valves opens at

_____ psi.

CONVERTER OPERATING PRESSURE	RELIEF VALVE SETTING
Low-Pressure System	100 - 120 psi
High-Pressure System	380-430 psi

Table 3. Converter-to-Relief Valve Relation.

c. From Table 3 find the setting of the relief valve used with the converter under test.

d. Compare the reading listed in step b with the relief valve setting listed in Table 3. The relief valve is (good/bad)

__________.

e. Put the rubber test hose on the leakage flowmeter of the tester.

f. Place the other end of the hose on the converter vent port.

g. If the ball in the flowmeter does rise from the zero mark, list the amount of leakage shown. The leakage is ________ LPM.

Number of Relief Valves Installed	Leakage Permitted
1	0.01 LPM
2	0.02 LPM

Table 4. Permitted Relief Valve Leakage.

h. From Table 4 find the amount of permissible leakage. Compare this setting with the leakage listed in step g. The reseating of the relief valve is (good/bad) _________.

i. Take the hose from the flowmeter and converter vent and place the hose on the bench.

j. Open the vent valve on the tester and vent the converter head pressure.

k. Open the supply valve and bleed off the supply pressure.

l. Close the supply valve. This leaves the tester in the vent position.

Note: At this time you would have a serviceable converter or one on which work would have to be done to make it serviceable.

PROJECT NUMBER 11: TF-20-1 CAPACITANCE TYPE LIQUID QUANTITY SYSTEM TRAINER

OBJECTIVES

After completing this project, you will be able to:

1. Set up the TF-20-1 tester for an empty converter capacitance check.

2. Take readings from the capacitance indicator on the tester.

3. Find the condition of a liquid oxygen converter probe assembly.

Standard of Performance:

Your ability to reach the objectives of this project will be evaluated by an instructor, using a criterion referenced checklist.

PROCEDURES

Note: All test leads that will be used are in the cover of the tester. The leads have numbers or letter-number combinations on them for identification. These leads are used with the tester. When you are given a numbered connection point, control switch or indicator in this project, look at the front panel diagram, inside the cover, for the location of the item.

1. Connect adapter lead #100038 from point 5 to a suitable ground.

2. Connect power cable #100033 and adapter cable #100034 together.

3. Connect the combined cable from point 4 to the power source.

4. Place power switch #1 to the ON position. The red light near the switch should come ON. Allow at least 5 minutes warm-up time.

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5. Connect the lead from point 11 to the HI-Z connector of the converter under test.

6. Connect the lead from point 12 to the LO-Z connector of the converter.

7. Set function selector switch #24 to TANK UNIT TEST-UNSH position.

8. Set CAP-RES CHECK switch #13 to CAP position.

9. Set the capacitance RANGE SELECTOR #6 to the lowest range that will give a stable reading (the indicator does not rotate continuously) on capacitance indicator #7. If the inner needle does cross above 100, place the range selector to the next higher multiplier.

> Note: Study the capacitance meter dial (figure 8). With the capacitance range selector in the x1 position, a reading of 43.25 MMF is obtained as shown in figure 8. The last decimal place is estimated by eye. In the x3 position this reading is 43.25 X 3 = 129.75 MMF. For the x10 and x50 positions the values are 432.50 MMF and 2162.50 MMF. Now apply what you have to read to interpret your reading on the converter you are checking.

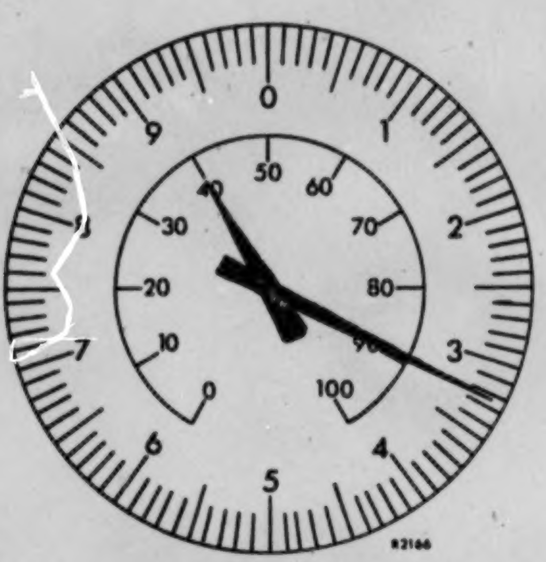

Figure 8. Capacitance Meter Dial.

12. Complete the statements.

a. The capacitance indicator reading is _____ MMF and the range selector is in the x____ position.

b. The MMF reading multiplied by the range selector position is ______ MMF.

c. Select the required reading from Table 5 for the size converter you are testing.

CONVERTER SIZE	REQUIRED READING
10 Liter	123.5 ± 1.0
25 Liter	303.5 ± 2.5
75 Liter	910.0 ± 7.5

Table 5. Converter Size-Capacitance Relation.

d. The required reading is ______ MMF and the number in step b (is/is not) ________ in the tolerance of the required reading. The converter capacitance probe is (good/bad) ________.

e. Have an instructor check your readings.

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PROJECT 12: REPAIR AND/OR REPLACEMENT OF A LIQUID OXYGEN CONVERTER, PRESSURE CLOSING VALVE OR RELIEF VALVE

OBJECTIVES

1. Repair and/or replace liquid oxygen converter part.

2. Apply anti-sieze tape to fittings of liquid oxygen systems.

3. Select common handtools necessary for LOX converter maintenance.

4. Observe all safety precautions involved during LOX converter maintenance.

Standard of Performance:

Your ability to reach the objectives will be evaluated by the instructor.

PROCEDURE

Note: In the field you will be required to remove and replace minor parts of LOX converters. This project will familiarize you with the handtools, equipment, procedures and safety precautions necessary to accomplish that task.

1. On a given converter, remove lines and tubing connected to the part, being careful not to twist any lines.

2. Remove common hardware securing the part to the converter assembly, and remove the part.

3. Place the part in a bench vise and remove all old fittings and tape, retape fittings. Have the instructor check your work at this time. INSTRUCTOR'S INITIALS ________

Install the fittings in the new valve exactly the way they came out of the old valve. (During taping, follow the instructions on the role of anti-sieze tape.)

4. Mount the new part on the converter assembly, reinstall common hardware and tighten.

5. Reinstall and/or connect tubing and lines disconnected during removal, and tighten tubing and lines.

Note: In the field, your converter would now be serviced with a few liters of liquid or gaseous oxygen, for the purpose of leak checking all the fittings. All lines found to be leaking would be tightened to stop the leak.

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PROGRAMMED TEXT

3ABR42331-PT-404

Technical Training

Aircraft Environmental Systems Mechanic

CYROTAINER CONSTRUCTION AND MAINTENANCE

9 November 1978

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.

Do Not Use on the Job.

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FOREWORD

This programmed text was prepared for use in the 3ABR42331 instructional system. The materials contained herein have been validated using 30 students enrolled in the 3ABR42331 course. Eighty percent of the students taking this text surpassed the criterion called for in the approved lesson objectives. The average student required 4.8 hours to complete the text.

OBJECTIVES

1. Match 8 of 10 components of the cryotainer with their function/ operation.

2. Identify without error, the safety precautions relative to cryotainers.

INSTRUCTIONS

This text is presented in small steps called "FRAMES." After each frame you will select correct statements, match names, and/or numbers to items. Compare your answer with the correct one found at the beginning of the next frame. If your answer is correct, go to the next frame. If your answer is wrong, read the frame again and see how the correct response was derived.

READ CAREFULLY AND DO NOT HURRY!!!!

Note: Upon completion of this programmed text you will use the equipment covered in this text while doing your oxygen lab projects.

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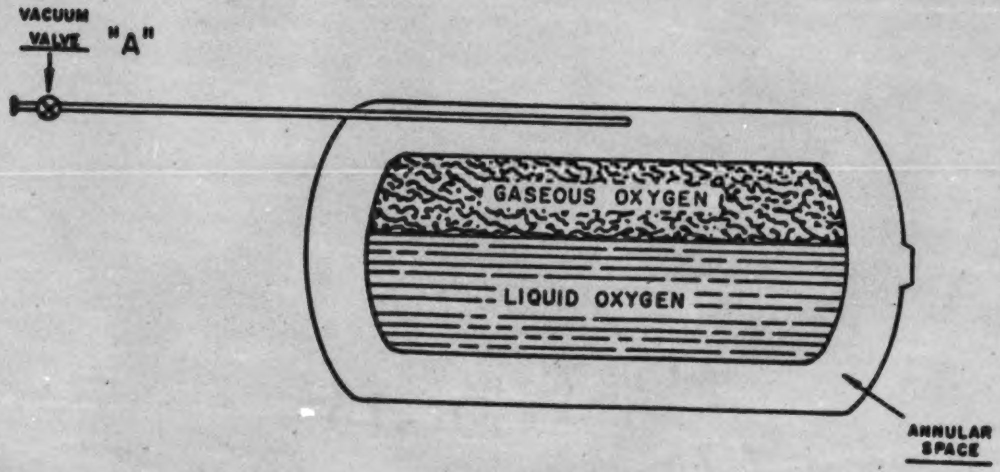
The storage of cryogenic fluids for many years has caused a problem. No refrigeration system was able to keep this liquid at a temperature low enough to keep it in a liquid state. Now liquid oxygen and liquid nitrogen can be stored successfully. They are stored in the same manner. Since our first concern is the storage of liquid oxygen, this Programmed Text refers to liquid oxygen.

Liquid oxygen must be kept at an extremely cold temperature (below -297°F) to keep it in a liquid state. Any heat causes it to boil and gas off. You can see the gassing off process taking place in water. Water will boil and gas off to a water vapor, when its temperature is raised above the boiling point. The more heat added to any liquid, the more it boils and evaporates.

There is no low cost way of refrigerating liquid oxygen to keep it in a liquid state; therefore, the only practical way to store it is to try to keep heat from getting to it. This is done by use of a cryotainer.

It was said earlier in the text that LOX must be kept in insulated tanks to stop it from boiling and thus changing from a liquid to a gas. To slow this boiling action down, one tank is placed inside another. The inner tank holds the liquid. The outer tank aids in insulating the inner tank. The space between the two tanks (annular space) is filled with an insulating material. A vacuum pump is attached to the line at the top of the tank. The vacuum valve is then opened and the air is pumped out. The valve is then safety wired shut to stop accidental opening. This valve will be color coded yellow and may be letter coded "A". These two items, the insulating material and vacuum in the annular space, provide the insulation for the inner tank. (See figure below)



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Frame 1 (Cont'd)

Circle the correct answer.

1. The space between the two tanks is called

   a. annular space.

   b. pressure.

   c. LOX.

   d. rupture.

2. The vacuum valve must be letter coded "A". TRUE or FALSE

3. The vacuum valve must be color coded

   a. blue.

   b. red.

   c. white.

   d. yellow.

4. Insulating material provide the only insulation for the inner tank. TRUE or FALSE

5. Air in the annular space is a good insulator. TRUE or FALSE

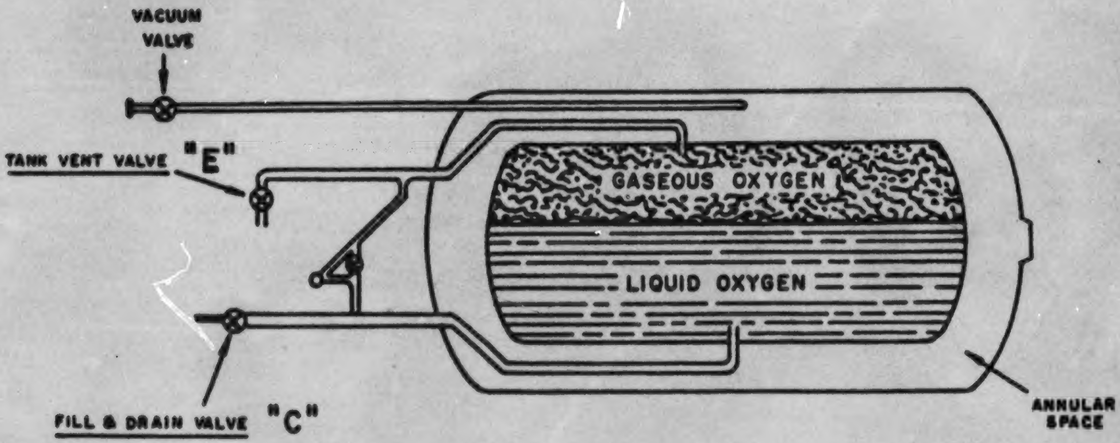
2855

Answers to Frame 1: 1. a 2. FALSE 3. d 4. FALSE
5. FALSE

Frame 2

There are 3 main control valves. All are the globe type with extended stems. The extended stem prevents the packing from freezing and reduces heat transfer from the hand-wheel to the valve body. The valve body is at the temperature of the liquid oxygen while the hand-wheel is cool to the operator.

There are two pipes that come from the inner tank. The top line from the inner tank is the vent pipe and has the vent valve attached. This valve is only closed when transferring (dispensing) liquid. At all other times, this valve will be open to let the liquid that is vaporizing, out of the tank. The valve is color coded red and may be letter coded "E". (See figure below). The line from the bottom inner tank is the fill and drain line with the fill and drain valve attached. The valve will be color coded blue and may be letter coded "C". This valve will only be opened when issuing or receiving LOX.



Circle the correct answer.

1. When you are not transferring liquid, the vent valve will be left in the

   a. closed position.

   b. middle position.

   c. open position.

   d. annular position.

Frame 2 (Cont'd)

2. The vent valve is color coded red.

   TRUE or FALSE

3. The fill and drain valve is color coded

   a. blue.

   b. red.

   c. white.

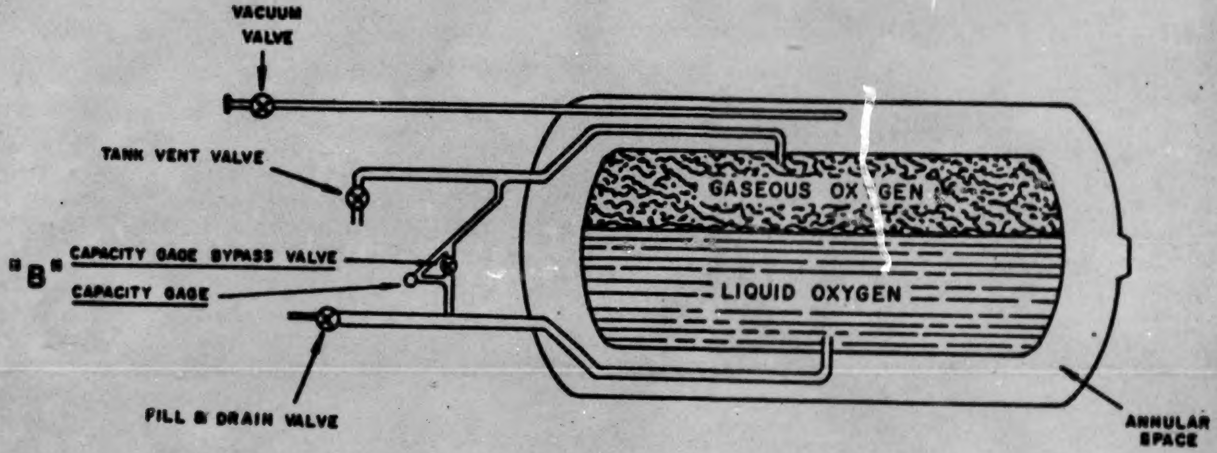
   d. yellow.

Answers to Frame 2: 1. c 2. TRUE 3. a

Frame 3

Located on the pressure line that connects the vent pipe and the transfer pipe is a capacity gage. As the name states, this gage shows the amount of liquid oxygen within the inner tank. This gage is sensitive to pressure and it can be damaged by pressure surges. Therefore, the gage is offset from the pressure line and is protected by a capacity gage bypass valve located in the pressure line.

The valve located in the pressure line is a safety device that protects the capacity gage. This valve is normally open, allowing pressure to "bypass" (go around) the capacity gage. The bypass valve should be closed only when you need to obtain the amount of LOX in the tank. As soon as you have obtained the amount of LOX within the tank, the bypass valve should be opened again. This valve will be color coded black and may be letter coded "B". (See figure below)


VACUUM VALVE
TANK VENT VALVE
"B"
CAPACITY GAGE BYPASS VALVE
CAPACITY GAGE
FILL & DRAIN VALVE
GASEOUS OXYGEN
LIQUID OXYGEN
ANNULAR SPACE

Frame 3 (Cont'd)

Circle the correct answer.

1. What valve is installed in the system to protect the capacity gage?

   a. Tank vent

   b. Capacity gage bypass

   c. Capacity gage

   d. Fill and drain valve

2. The capacity gage bypass valve is normally in the

   a. open position.

   b. closed position.

   c. up position.

   d. side position.

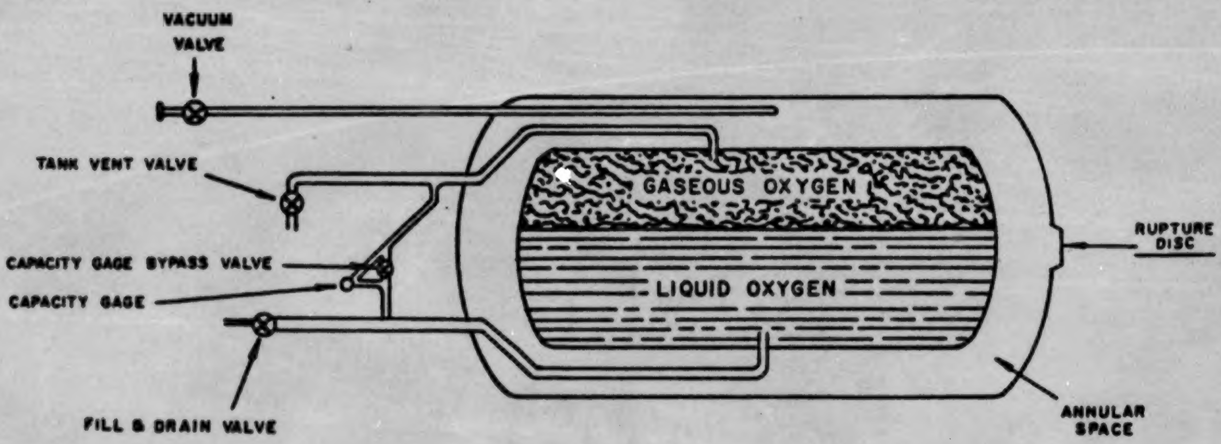
3. The capacity gage bypass valve is color coded red. TRUE or FALSE

2859

Answers to Frame 3: 1. b 2. a 3. FALSE

Frame 4

Earlier in this text we said that pressure buildup within the LOX tank can (under the right conditions) present a hazard to personnel and equipment. For example, if the shell of the inner tank should rupture and leak liquid oxygen into the annular space between the inner and outer tanks, there could be a dangerous buildup of pressure between the two tank shells. To prevent the outer tank from being damaged or blown up from excessive pressures, a safety device is installed in the shell of the outer tank. This safety device is a rupture disc. The rupture disc is set to blow out at a pressure low enough to prevent damage to the outer tank shell. Since LOX tanks are made by several different companies and since each company has different pressure settings on the tanks' safety devices, we will not discuss the pressure settings of these safety devices in this text. (See figure below). A complete description of the rupture disc and its blowout pressure is in TO 37C2-8-1-101.


VACUUM VALVE
TANK VENT VALVE
GASEOUS OXYGEN
CAPACITY GAGE BYPASS VALVE
CAPACITY GAGE
LIQUID OXYGEN
RUPTURE DISC
FILL & DRAIN VALVE
ANNULAR SPACE

Circle the correct answer.

1. What is the name of the auto pressure buildup device on the outer tank?
   - a. Vacuum valve
   - b. Rupture disc
   - c. Tank vent
   - d. Capacity gage

2. All outer tank rupture discs are set at the same pressure.

   TRUE or FALSE

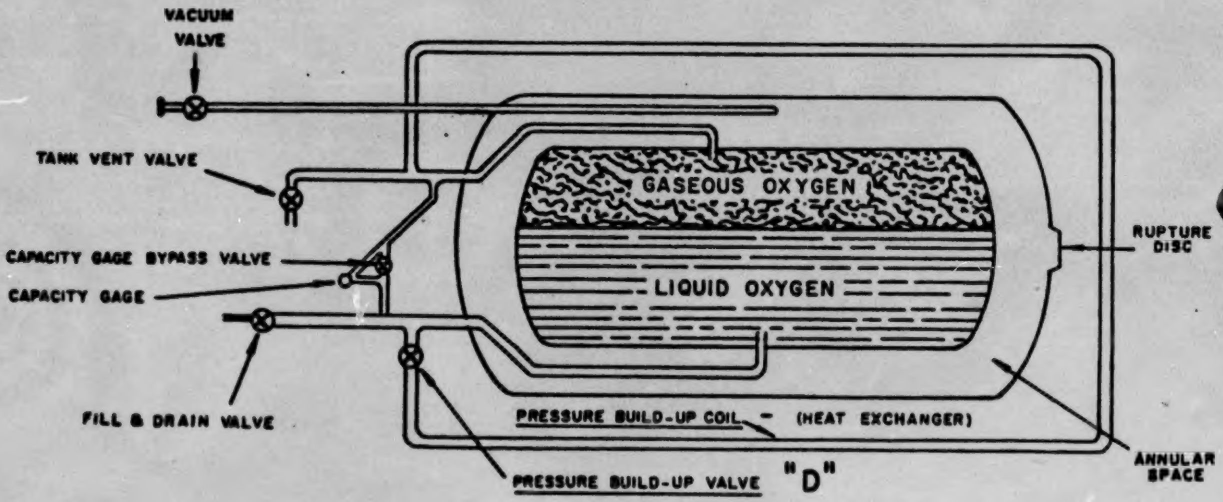
241

2860

Answers to Frame 4: **1. b** **2. FALSE**

Frame 5

LOX tanks do not have pumps to aid in the rapid transfer of LOX. So some other way must be used to move the liquid. The other way is pressure. As you already know, if the tank vent is closed, pressure will start to build in the tank. But this is a slow process. To speed this process, a pressure buildup valve and coil are attached to the fill and drain line. When the pressure buildup valve is opened (see figure) LOX will flow through the pressure buildup coil (heat exchanger) where it is changed to a gas. From the heat exchanger, the gas follows the pipe which joins the tank vent pipe (remember the tank vent is closed). The gas will then flow back into the gaseous portion of the tank and will apply added pressure to the liquid which allows a more rapid transfer of LOX. This valve will remain closed except when building up pressure in the tank. The pressure buildup valve will be colored coded white and may be letter coded "D".


VACUUM VALVE
TANK VENT VALVE
CAPACITY GAGE BYPASS VALVE
CAPACITY GAGE
FILL & DRAIN VALVE
GASEOUS OXYGEN
LIQUID OXYGEN
RUPTURE DISC
PRESSURE BUILD-UP COIL - (HEAT EXCHANGER)
ANNULAR SPACE
PRESSURE BUILD-UP VALVE "D"

Circle the correct answer.

1. The pressure buildup coil changes gas to liquid? TRUE or FALSE

2. The pressure buildup valve will be open at all times except during transfer? TRUE or FALSE

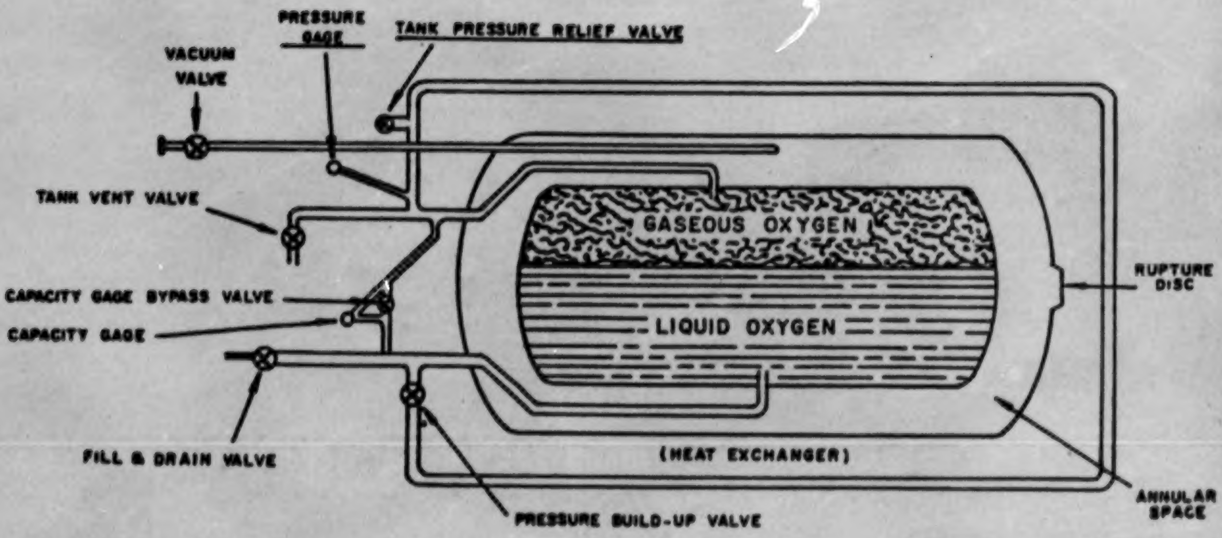
3. The pressure buildup valve is color coded white. TRUE or FALSE

Answers to Frame 5: 1. FALSE 2. FALSE 3. TRUE

Frame 6

Just above the point that the pressure buildup coil joins the tank vent line is a direct reading gage (Pressure Gage). This is used to tell how much pressure is built up within the vapor portion of the inner tank.

Located just above the pressure gage in the pressure build up line is a protective device, the Tank Pressure Relief Valve. This valve will relieve excessive pressure in the inner tank. (Depending on the type of tank the valve will operate either manually or automatically.) See figure below.


PRESSURE GAGE
TANK PRESSURE RELIEF VALVE
VACUUM VALVE
TANK VENT VALVE
GASEOUS OXYGEN
RUPTURE DISC
CAPACITY GAGE BYPASS VALVE
CAPACITY GAGE
LIQUID OXYGEN
FILL & DRAIN VALVE
(HEAT EXCHANGER)
ANNULAR SPACE
PRESSURE BUILD-UP VALVE

8862.

Frame 6 (Cont'd)

Circle the correct answer.

1. What valve is installed to relieve excessive pressure in the inner tank?

   a. Tank vent

   b. Pressure build up

   c. Rupture disc

   d. Tank pressure relief

2. What is used to tell how much pressure has been built up in the inner tank?

   a. Capacity gage

   b. Pressure gage

   c. Vacuum gage

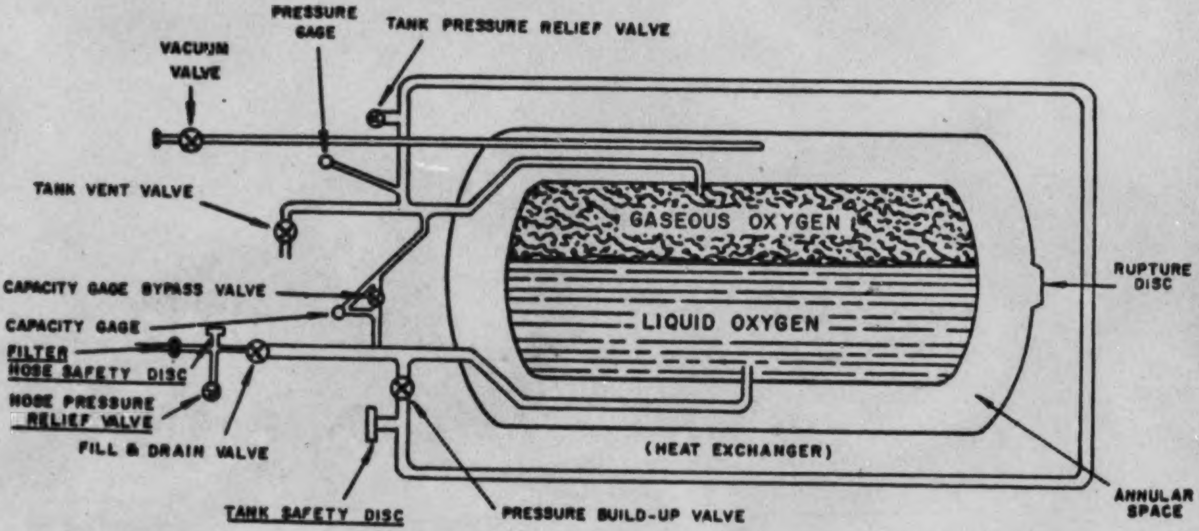
   d. Annular space

Answers to Frame 6: 1. d 2. b

Frame 7

Another relief valve is located in the fill and drain line. This is the Hose Pressure Relief Valve. This relieves excessive pressure in the transfer hose and, depending on the type of tank, will be manually or automatically operated. There are two more safety devices, one located in the pressure buildup line and one in the fill and drain line. These are safety discs. If for example, the hose pressure relief valve or tank pressure relief valve were frozen in the closed position, these discs (Hose Safety Disc and Tank Safety Disc) are designed to blow out if the pressure in the hose or tank continued to rise.

The last item is of the Filter located in the fill and drain line. The filter is the metal porous type. This unit, as the name implies, filters LOX.


PRESSURE GAGE
TANK PRESSURE RELIEF VALVE
VACUUM VALVE
TANK VENT VALVE
GASEOUS OXYGEN
RUPTURE DISC
CAPACITY GAGE BYPASS VALVE
CAPACITY GAGE
FILTER
HOSE SAFETY DISC
LIQUID OXYGEN
HOSE PRESSURE RELIEF VALVE
FILL & DRAIN VALVE
(HEAT EXCHANGER)
ANNULAR SPACE
TANK SAFETY DISC
PRESSURE BUILD-UP VALVE

Circle the correct answer.

1. The purpose of the hose pressure relief valve is to relieve normal hose pressure.

   TRUE or FALSE

2. The safety disc will blow out automatically if the relief valves are frozen closed and pressure in the inner tank continues to rise.

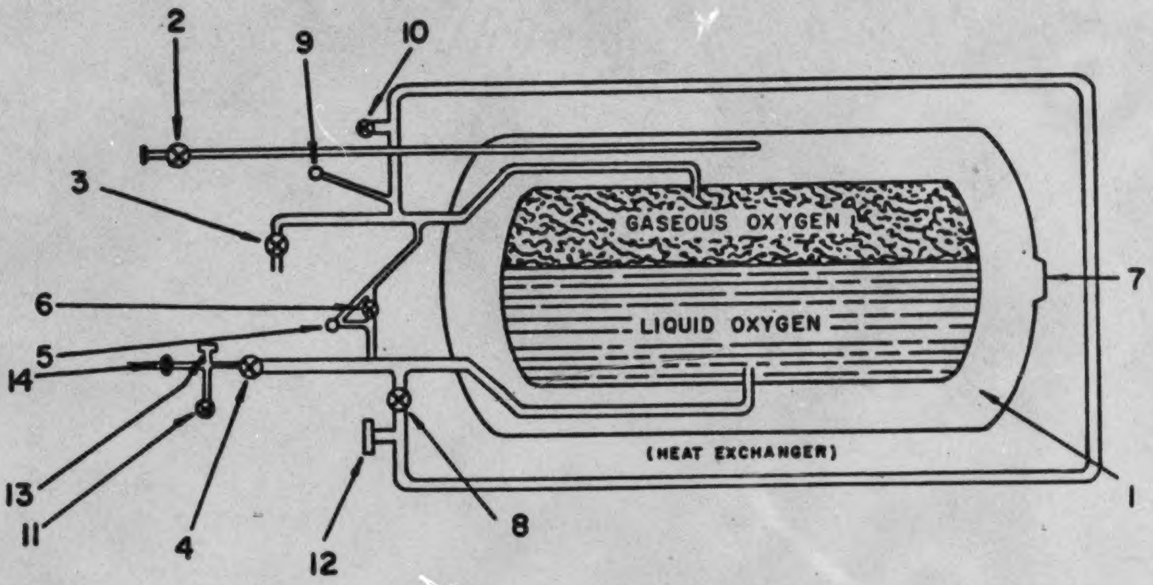
   TRUE or FALSE.

2864

Answers to Frame 7: 1. FALSE 2. TRUE

Frame 8

Using the diagram, enter the number that correctly identifies the components that make up a liquid oxygen facility. If you are not sure of the answers go back and review the information.



2
9
10
3
GASEOUS OXYGEN
7
6
LIQUID OXYGEN
5
14
(HEAT EXCHANGER)
13
11
4
12
8
1

a. _____Vacuum valve

b. _____Pressure buildup valve

c. _____Tank safety disc

d. _____Annular space

e. _____Hose pressure relief valve

f. _____Rupture disc

g. _____Hose safety disc

h. _____Tank vent valve

i. _____Tank pressure relief valve

j. _____Fill and drain valve

k. _____Pressure gage

l. _____Capacity gage

m. _____Capacity gage bypass valve

n. _____Filter

2865

Answers to Frame 8:
a. 2 b. 8 c. 12 d. 1 e. 11 f. 7
g. 13 h. 3 i. 10 j. 4 k. 9 l. 5
m. 6 n. 14

Frame 9

Before any LOX transfer or receiving operations are done, the valves must be properly positioned. Valves should not be tightened-down more than hand tight (using gloved hand only). The use of additional levers, breaker bars, etc will squeeze out the teflon seat. This will cause premature failure of the valves.

The following chart will show the correct valve positions for transferring, receiving, and storing LOX.

Valves		FUNCTIONS			
Color	Name	Filling	Pressure Buildup	Transfer	Liquid Storage
Black	Capacity Gage	Open	Open	Open	Open
Blue	Fill and Drain	Open	Closed	Open	Closed
White	Pressure Buildup	Closed	Open	Closed	Closed
Red	Vent	Open	Closed	Closed	Open

If the LOX tank is empty and not used, the vent valve should be closed.

Match the lettered items to their corresponding numbered items. More than one lettered item may be used.

_____1. Open for transfers	a. Black colored
_____2. Closed when filling	b. Tightening valves
_____3. Open when storing LOX	c. Pressure buildup valve
_____4. Using gloved hand	d. Vent valve
_____5. Open for all operations	e. Blue valve

2866

Answers to Frame 9: 1. a 2. c 3. a&d 4. b 5. a

Frame 10

The most common method of filling LOX tanks is through the fill and drain system. Before starting a LOX transfer operation, determine the amount of liquid in each tank to be used in the operation, to insure the tank isn't empty. This is done by closing the Capacity Gage Bypass Valve on each LOX tank. After getting the reading, remember to open the Capacity Gage Bypass Valve. This valve must be opened to prevent damage to the Capacity Gage.

Caution: Always leave the Capacity Gage Bypass Valve open when not taking a reading. If the valve is closed during a filling operation, there is a possibility of damage to the gage as a result of surging pressure against the gage mechanism.

Circle the correct answer for each of the following questions.

1. Why is the Capacity Gage Bypass Valve closed on the LOX tank from which you will transfer?
   - a. To prevent damage to Capacity Gage.
   - b. To make sure the tank is not empty.
   - c. To use as ready reference for inventory purposes.
   - d. To prevent surging of pressure.
2. What is the most common method of filling a LOX tank?
   - a. Through the Capacity Gage Bypass line.
   - b. Through the valve color coded black.
   - c. Through the valve color coded white.
   - d. Through the fill and drain system.
3. When would there be a possibility of Capacity Gage damage during a filling operation?
   - a. Capacity Gage Bypass Valve left open.
   - b. Fill and drain system clogged.
   - c. Rupture in fill and drain system.
   - d. Capacity Gage Bypass Valve left closed.

Answers to Frame 10: 1. b 2. d 3. d

Frame 11

Before liquid can be transferred, enough pressure must be built up in the LOX tank.

> Caution: Check tank pressure and hose pressure relief valves for free operation before building up tank pressure.

To build up pressure in a tank for transferring LOX, the valves must be properly positioned. The following chart is the portion of the chart in Frame 18 that covers the pressure buildup operation.

Valves		Function
Color	Name	Pressure Buildup
Black	Capacity Gage	Open
Blue	Fill and Drain	Closed
White	Pressure Buildup	Open
Red	Vent	Closed

When doing a pressure buildup operation, first make sure the Capacity Gage Bypass Valve is open. Then check the Fill and Drain Valve to make sure that it is closed hand tight. Now, close the red color coded Vent Valve. After the Vent Valve has been closed, SLOWLY open the Pressure Buildup Valve. While opening the Pressure Buildup Valve, watch the pressure increase on the pressure gage. Before the desired pressure is reached, close the Pressure Buildup Valve. The valve is closed before the desired pressure is reached because of the excess liquid in the pressure buildup coil. The expanding of this excess liquid will cause the pressure to be more than what is needed for transferring. For most transfers, 30 psi will be the desired pressure. Do not pressurize the LOX tank over 50 psi. Now, open the Vent Valve. You do not want to confine LOX.

Circle the correct answer for each of the following questions.

1. Which valve should be checked first for a transfer operation?

   a. Fill and Drain Valve.

   b. White color coded valve.

   c. Capacity Gage Bypass Valve.

   d. Red color coded valve.

2. Opening which valve actually allows the build up of a pressure in a LOX tank?

   a. Capacity Gage Bypass Valve.

   b. Vent Valve.

   c. Fill and Drain Valve.

   d. Pressure Buildup Valve.

3. Transferring of LOX can be started at what desired pressure?

   a. 50 psi.

   b. After the pressure buildup coil is empty.

   c. 30 psi.

   d. Before the pressure buildup valve is closed.

4. What would cause pressure in a LOX tank to exceed the desired transfer pressure?

   a. Closing pressure buildup valve too early.

   b. Liquid in pressure buildup coil.

   c. Leaving vent valve open.

   d. Not operating hose and tank pressure relief valves.

2969

Answers to Frame 11: 1. c 2. d 3. c 4. b

Frame 12

So far you have made sure that the LOX tank from which you will transfer (source tank) has enough LOX for the transfer operation and you have built up enough pressure in the source tank for transferring LOX. Now, you will have to connect the transfer hose to both the LOX storage tank and the 50 gallon LOX cart that you will be filling. First of all, remove the dust cover from the fill and drain line on the storage tank. Now, remove the dust cover from one end of the transfer hose. Connect the open end of the transfer hose to the storage tank fill and drain line. Remove the dust cover from the uncoupled end of the transfer hose. Place this open end of the transfer hose into a drip pan. Slightly open the Fill and Drain Valve on the source tank. Allow a small amount of liquid into the hose. When the liquid starts coming from the open end of the transfer hose, close the Fill and Drain Valve on the storage tank. The liquid in the transfer hose will evaporate. This evaporation action will clean (purge) the hose. Now you can remove the dust cover from the fill and drain line on the receiving tank. Then connect the transfer hose to the receiving tank.

Circle the correct answer for each of the following questions.

1. The transfer hose is connected to which tank first?

   a. Receiving tank

   b. Transport tank

   c. 50 gallon tank

   d. Source tank

2. What is done with the open end of the transfer hose before it is purged?

   a. Connected to receiving tank.

   b. Placed in drip pan.

   c. Remains closed when purging.

   d. Placed on concrete pad.

3. Why is the transfer hose purged?

   a. To cool the hose.

   b. To cool the hose coupling.

   c. To clean the hose.

   d. To check for obstructions

2870

Answers to Frame 12: 1. d 2. b 3. c

Frame 13

If the LOX tank is empty at the time it is to be filled, you will first have to cool it down. To cool down a receiving tank, slowly open the Fill and Drain Valve on the source tank. Open it only enough to permit a partial flow of liquid. Maintain this reduced flow rate until the receiving tank will be cooled down. This process will require several minutes. A receiving tank will be considered to be cooled enough when the gas escaping from the vent slows down.

Once the receiving tank is cooled down enough, or if the tank is already cool, fully open the Fill and Drain Valve on the source tank. Leave the valve open until liquid LOX starts spurting from the vent on the receiving tank. This spurting of liquid LOX from the vent will indicate the receiving tank is full. At this point, close the Fill and Drain Valve on the source tank, and open the Vent Valve. Then close the Fill and Drain Valve on the receiving tank.

Circle the correct answer for each of the following questions.

1. What flow rate is used when cooling down a LOX tank?

   a. Reduced flow rate until gas coming from the vent slows down.

   b. Full flow rate until gas escapes from the vent.

   c. Reduced rate until liquid escapes from the vent.

   d. Full flow rate until liquid escapes from the vent.

2. What is indicated by liquid LOX coming from the receiving tank's vent?

   a. Tank is cooled down enough to increase flow.

   b. Leak in tank piping.

   c. Tank is full.

   d. Leak at transfer hose coupling.

Answers to Frame 13: 1. a 2. c

Frame 14

After the receiving tank is full, the transfer hose must be disconnected and stored. Also, a quantity reading will be taken. After the receiving tank is full, do not immediately disconnect the transfer hose. The LOX that is still in the transfer hose will cause pressure to be exerted on the hose. This pressure is relieved by pulling the control knob for the Hose Pressure Relief Valve. Hold this valve open until the pressure in the hose ceases to escape. Then disconnect the transfer hose from the receiving tank. Replace the dust covers on the hose and the fill and drain line on the receiving tank. Now, remove the hose from the source tank. Again, replace the dust covers on the other end of the transfer hose and the fill and drain line on the source tank. The transfer hose will be placed in the hose trough or other protective receptacle after the dust caps have been replaced.

Warning: Some liquid may remain in the hose even after the pressure has been released. Use caution at all times when disconnecting the transfer hose. Keep hose pointed away from personnel.

Circle the correct answer for each of the following questions.

1. Before the transfer hose is disconnected from the receiving tank, what must be done?

   a. Open Vent Valve.

   b. Pull Hose Pressure Relief Valve.

   c. Close Vent Valve.

   d. Push Hose Pressure Relief Valve.

2. What causes pressure to remain in the transfer hose after the Fill and Drain Valves are closed?

   a. Sudden stopping of the flow of LOX.

   b. Liquid LOX remaining in the transfer hose.

   c. Back flow of liquid LOX.

   d. Liquid LOX escaping from the vent.

2872

Answers to Frame 14: 1. b 2. b

Frame 15

The final step of a LOX transfer is to obtain a quantity reading. This may be done by determining the amount of LOX in either the source or receiving tank. However, the quantity reading will not be taken until the liquid has stabilized in the tank. The time required for the liquid to stabilize is usually 10 minutes. The reading is obtained by fully closing the Capacity Gage Valve. Do not forget to reopen the Capacity Gage Valve. The quantity of liquid transferred will be recorded on an AFTO Form 134.

Circle the correct answer for each of the following questions.

1. What must occur before a quantity reading is taken for a LOX transfer?

   a. The receiving tank must be warmed up.

   b. The liquid must be out of the transfer line.

   c. The source tank must be warmed up.

   d. The liquid must not be moving.

2. How long will the Capacity Gage Valve be left closed when getting a quantity reading?

   a. 10 minutes.

   b. Until the reading is taken.

   c. Until the liquid has stabilized.

   d. It is open at all times.

Answers to Frame 15: 1. d 2. b

Frame 16

Review Exercise

For the first set of questions, indicate whether the statement is true or false.

1. On LOX tanks, the Capacity Gage is color coded black.

_____ True

_____ False

2. The Vent Valve and the Pressure Buildup Valve are the only valves open to buildup pressure for a transfer operation.

_____ True

_____ False

3. The valve that is color coded blue on LOX tanks is the Fill and Drain Valve.

_____ True

_____ False

4. The Tank Pressure Relief Valve is used to relieve pressure after a LOX transfer is completed.

_____ True

_____ False

5. The Vent Valve on LOX tanks is color coded red.

_____ True

_____ False

6. Valves on LOX tanks should be closed hand tight using a gloved hand only.

_____ True

_____ False

7. The blue color coded valve on LOX tanks is the Pressure Buildup Valve.

_____ True

_____ False

2374

Frame 16 (Cont'd)

8. After a LOX transfer is finished, the pressure in the transfer hose is relieved by pulling the Hose Pressure Relief Valve open.

_____ True

_____ False

For the rest of the questions, circle the correct answer for each of the questions.

9. How can you tell when the receiving tank is full during a transfer operation?

    a. Gas escaping from the vent.

    b. Transfer hose will frost over.

    c. Gas escaping from the bypass line.

    d. Liquid escaping from the vent.

10. Why is a small amount of liquefied LOX allowed into the transfer hose before it is connected to the receiving tank?

    a. Make sure the source tank's Fill and Drain Valve opens freely.

    b. Cool the attached coupling for a tighter fit.

    c. Check for leaks in the transfer hose.

    d. Purge the transfer hose.

11. What two valves are open when storing LOX?

    a. Capacity Gage Valve and Fill and Drain Valve.

    b. Capacity Gage Valve and Pressure Buildup Valve.

    c. Capacity Gage Valve and Vent Valve.

    d. Fill and Drain Valve and Vent Valve.

12. After a LOX transfer operation is finished, what is done after a 10 minute wait?

    a. Reopen the Vent Valve.

    b. Close the Vent Valve.

    c. Close the Capacity Gage Valve.

    d. Reopen the Pressure Buildup Valve.

13. What is the maximum pressure that should not be exceeded in a LOX tank?

    a. 30 psi.

    b. Until gas starts escaping from the Vent Valve.

    c. 50 psi.

    d. Until the fill and drain line is full.

14. Before an empty receiving tank is filled, what must be done to the tank?

    a. Cooled down

    b. Purged

    c. Vacuum checked

    d. Tank cleaned

15. Why should caution be used when disconnecting the transfer hose?

    a. Prevent contamination from entering the transfer hose.

    b. Prevent introduction of hydrocarbons.

    c. Liquid may remain in the hose after pressure is released.

    d. Liquid may leak from the bypass line.

16. Why should the Pressure Buildup Valve be closed before the desired transfer pressure is reached?

    a. Prevent pressure from exceeding 50 psi.

    b. Because of liquid in the pressure buildup coil.

    c. So LOX will not be confined.

    d. Prevent damage to the Capacity Gage Bypass valve.

17. The quantity of LOX transferred will be recorded on what form?

    a. AF Form 134

    b. AF Form 371

    c. AFTO Form 134

    d. AFTO Form 371

18. What two valves are checked for free operation before building up pressure in a LOX tank?

    a. Capacity Gage Valve and Fill and Drain Valve.

    b. Tank Pressure Relief Valve and Vent Valve.

    c. Capacity Gage Valve and Vent Valve.

    d. Hose Pressure Relief Valve and Tank Pressure Relief Valve.

2876

Answers to Review Exercises, Frame 16

1. True
2. False
3. True
4. True
5. True
6. True
7. False
8. True
9. d
10. d
11. c
12. c
13. c
14. a
15. c
16. b
17. c
18. d

2877

Frame 17

A general inspection is to be performed on all LOX equipment. The following chart lists the items to be inspected, what the items are to be inspected for, and how often each item is to be inspected.

ITEM	INSPECTED FOR	FREQUENCY
Instruments	Cracked or broken gage faces.	Daily
	Damaged mountings and connections.	Daily
Hose	Excessive scuff guard wear.	Daily
	Frayed wire in braid.	Daily
Fill and Drain Valve	Physical damage and worn or damaged parts.	Daily
Cabinet	Cleanliness and absence of foreign objects.	Daily
	Missing or damaged valve handles.	Daily
Valves	Ease of operation.	Daily
	Leaks in bonnet or packing.	Daily
Brake	Proper and easy operation.	Daily
Tank	General physical condition and loose or missing hardware.	Daily
Tires	Cracks, underinflation, deterioration, or other damage (30 psi pressure).	Monthly
Painted Surface	Corrosion, Rust, Damage, Peeling (Spot paint if deterioration constitutes less than 25 percent of the entire surface to be refinished; if 25 percent or more, refinish entire surface.).	Monthly

2878

Frame 17 (Cont'd)

In the following matching exercise, the lettered items are brief descriptions of what a specific item on the LOX equipment must be inspected for. Match the lettered items to their corresponding numbered items.

_____1. Brake

_____2. Valves

_____3. Cabinet

_____4. Painted Surfaces

_____5. Fill and Drain Valve

_____6. Tires

_____7. Instruments

_____8. Tank

_____9. Hose

a. Daily cracks and deterioration

b. Monthly for corrosion and peeling

c. Daily for loose or missing hardware

d. Monthly for ease of operation

e. Daily for proper and easy operation

f. Monthly for cracks, underinflation and deterioration

g. Daily for cleanliness and absence of foreign objects

h. Monthly for loose or missing parts

i. Daily for physical damage and worn or damaged parts

j. Daily for ease of operation

k. Daily for frayed wire in braid

l. Daily for damaged mountings and connections

Answers to Frame 17:
__e__ 1. __j__ 2. __g__ 3. __b__ 4. __i__ 5.
__f__ 6. __l__ 7. __c__ 8. __k__ 9.

Frame 18

Review Exercise

Indicate whether each of the following statements are true or false.

1. Brakes on mobile LOX trailers will be inspected monthly for easy operation.

   _____ True

   _____ False

2. The Fill and Drain Valve is inspected daily for physical damage and worn or damaged parts.

   _____ True

   _____ False

3. The instruments on LOX equipment will be checked for damaged mountings and connections monthly.

   _____ True

   _____ False

4. If less than 30 percent of the painted surface of LOX equipment to be refinished has deteriorated, the equipment will only be spot painted.

   _____ True

   _____ False

5. Each day the tank of LOX equipment is inspected for loose or missing parts.

   _____ True

   _____ False

6. Instruments on LOX equipment will be inspected for cracked or broken gage faces daily.

   _____ True

   _____ False

7. Valves on LOX equipment are inspected daily for leaks in bonnet or packing.

____ True

____ False

8. Excessive wear of the hose scuff guard is checked daily.

____ True

____ False

9. Tires on mobile LOX trailers are inspected daily to make sure they have 30 psi pressure.

____ True

____ False

10. LOX equipment cabinets are inspected daily for missing or damaged valve handles.

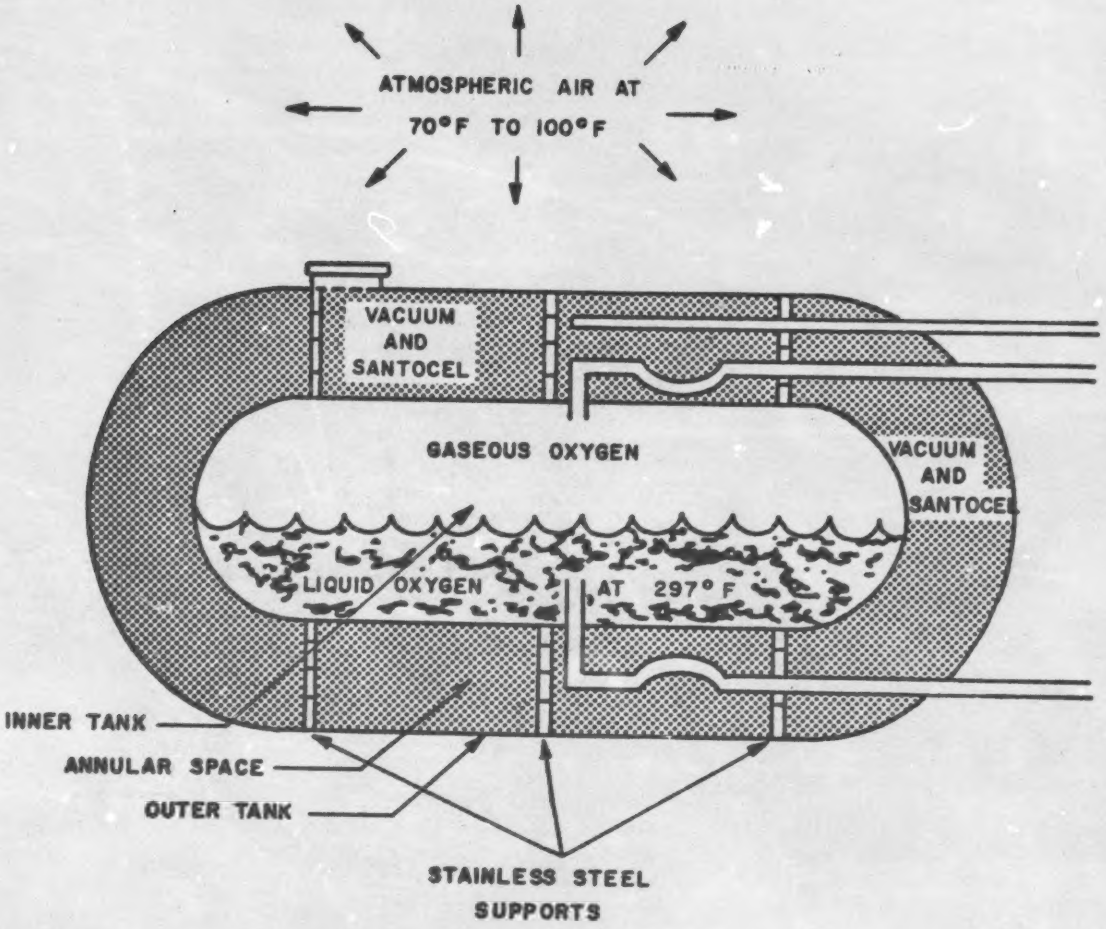
____ True

____ False

Review Exercise Answers, Frame 18: 1. False 2. True 3. False
4. False 5. True 6. True
7. True 8. True 9. False
10. True

Frame 19

We spoke of the construction of LOX storage tanks in the previous frames. In the next frames we are to talk about HEAT LOSS IN LOX STORAGE TANKS. Heat can be moved in three ways; conduction, convection, and radiation. The transfer of heat can be reduced or slowed down but it cannot be stopped. Heat transfer can be reduced to the point where it is practical to keep liquid oxygen. By reducing the amount of heat to the liquid oxygen in a LOX tank, the loss through vaporization is less. Note in the sketch below how the tank is built.


ATMOSPHERIC AIR AT
70°F TO 100°F
VACUUM AND SANTOCEL
GASEOUS OXYGEN
VACUUM AND SANTOCEL
LIQUID OXYGEN AT 297° F
INNER TANK
ANNULAR SPACE
OUTER TANK
STAINLESS STEEL SUPPORTS

Cryotainer Construction to reduce heat transfer.

NO RESPONSE REQUIRED

2882

Answers to Frame 19: NO RESPONSE REQUIRED

Frame 20

CONDUCTION

Heat is moved by conduction through some solid material such as metal, wood, or glass. Each type of material will move heat at a different degree or speed. To lower heat transfer by conduction, the aluminum inner tank is fastened to the aluminum outer tank by stainless steel supports, which are poor conductors of heat when compared with aluminum. Thus, the transfer of heat to the inner tank by conduction is slowed down. Look at the sketch in Frame 19, page 31.

Select the following statement(s) that is/are true.

_____1. Heat conduction is through a solid material.

_____2. Stainless steel is a good conductor of heat.

Answers to Frame 20: T 1. F 2.

Frame 21

CONVECTION

Heat moved with a fluid as a carrier or conveyer, is convection. All gas and liquids are fluids, thus, air which is a fluid is a good conveyor. One example is the heat given off by an old-fashioned heating stove or a camp heater. As the air near the stove gets heated, it expands and becomes lighter. This will cause the air to rise. Cool air from the floor then moves toward the stove and is heated. This continuous movement of air heats the whole room. Heat transfer by convection is reduced in an oxygen container by removing most of the air in the annular space with a vacuum pump. The annular space is the space between the inner and outer tanks as you saw in the sketch in Frame 19.

Circle the letter in front of the correct answer.

1. Fluids are

    a. water and oil.

    b. water and air.

    c. liquids and mercury.

    d. liquids and gases

2. Heat given off by a stove is called

    a. conduction.

    b. convection.

    c. radiation.

    d. conduction and convection.

2884

Answers to Frame 21: 1. d 2. b

Frame 22

RADIATION

Heat that travels through space by waves or rays in place of air currents is known as heat transfer by radiation. The air is not heated as in the case of convection. A good example of this heat transfer is the radiant heat received from the sun. We know the earth receives most of its heat from the sun. An object on the earth absorbs the heat from the sun. The only known way to control radiant heat is to reflect the rays away from the object. Since the heat rays can travel through a vacuum, the annular space of the storage tanks is filled with a white powdery insulation. This reflects most of the heat rays away from the inner tank and the liquid oxygen, sketch in Frame 19.

Of the three types of heat transfer acting on the liquid oxygen tank, man can only change the transfer of heat by convection. The degree of vacuum in the annular space is what he controls.

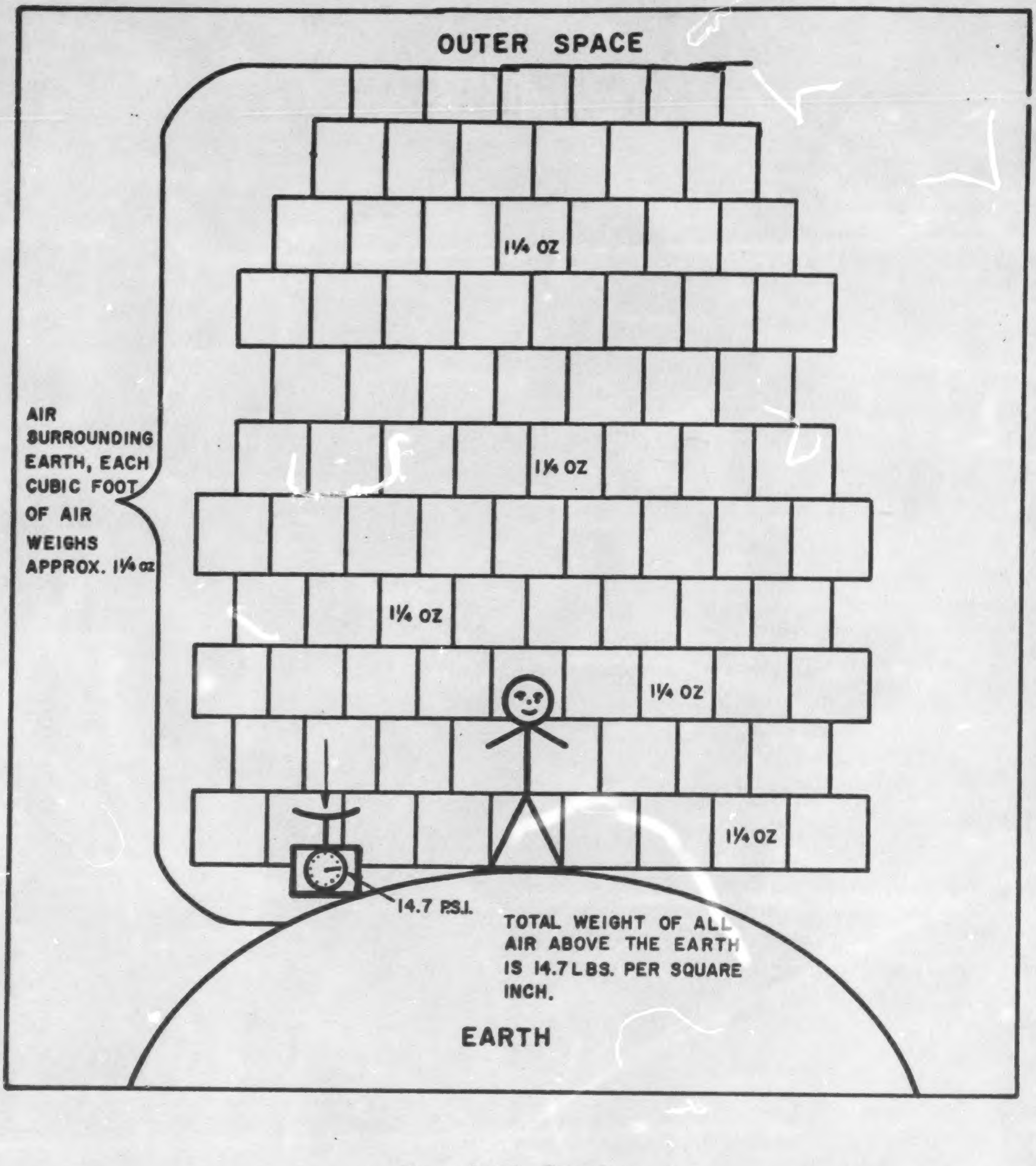
Complete the following statements by writing in the correct word or words.

1. Heat received from the sun is called ________________________.

2. Radiant heat may be controlled by reflecting the rays __________ __________ the object.

3. Heat rays ____________ travel through a vacuum.

GRAPH ILLUSTRATION OF WHAT CAUSES ATMOSPHERIC PRESSURE ON EARTH
Reference Frame 23


OUTER SPACE
1¼ OZ
1¼ OZ
1¼ OZ
1¼ OZ
1¼ OZ
AIR SURROUNDING EARTH, EACH CUBIC FOOT OF AIR WEIGHS APPROX. 1¼ oz
14.7 P.S.I.
TOTAL WEIGHT OF ALL AIR ABOVE THE EARTH IS 14.7 LBS. PER SQUARE INCH.
EARTH

Atmospheric Pressure.

2886

Answers to Frame 22: 1. radiation 2. away from 3. can

Frame 23

VACUUM

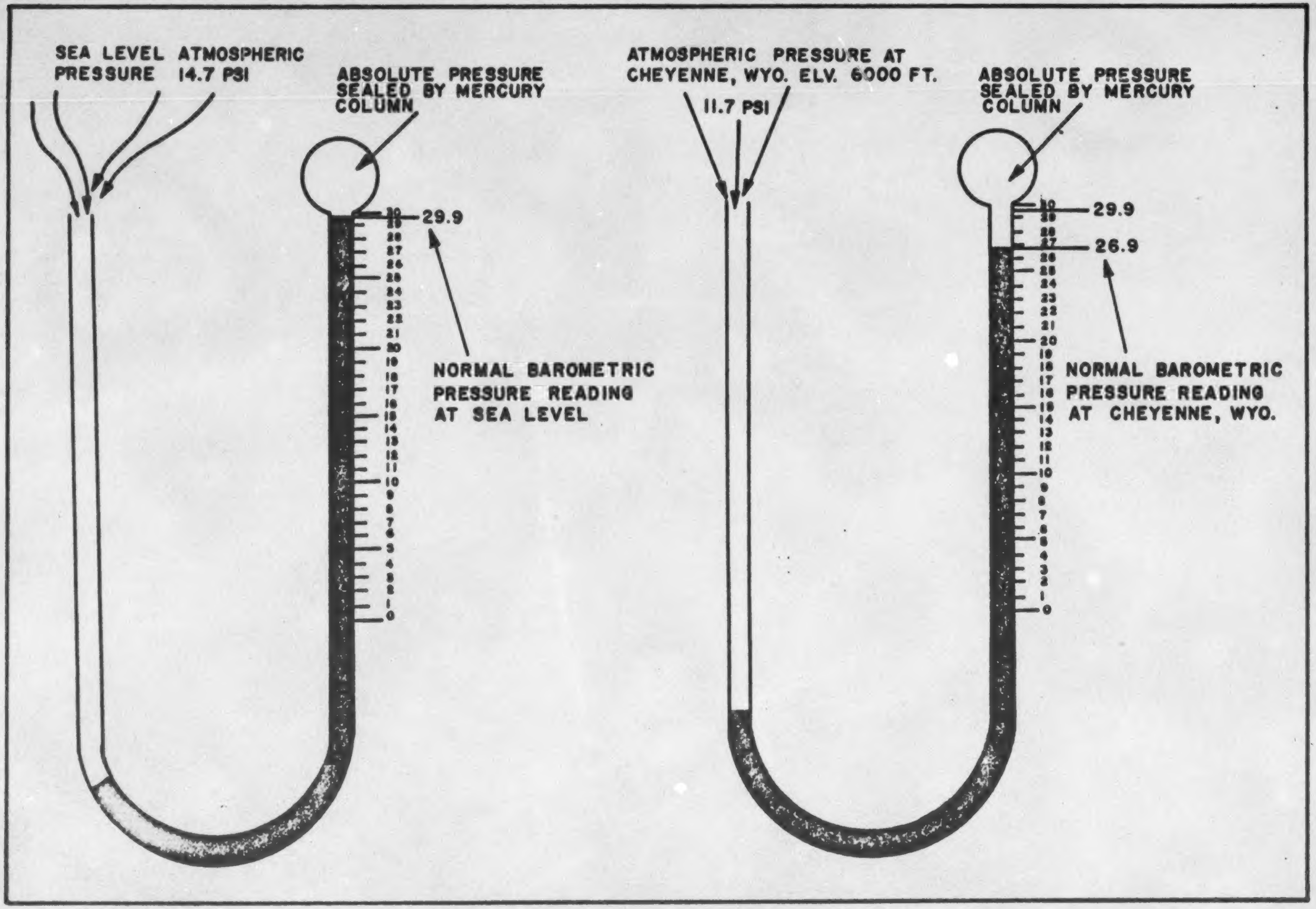
A perfect vacuum, related to liquid oxygen storage tanks, is the absence of all atmospheric air pressure. Air is all around the earth and extends out into space. The weight of all this air puts a pressure on the earth of 14.7 pounds per square inch at sea level. Look at the graph illustration (page 35) of what causes atmospheric pressure. This pressure (atmospheric) is in all cavities and tanks. The atmospheric pressure becomes less above sea level. For each 1000 feet above sea level, the pressure drops one-half pound per square inch (psi). Any pressure less than atmospheric pressure is a partial vacuum. Note the sketch on page 37 shows atmospheric pressure pushing a mercury column up the sealed (vacuum) end of the tube. The pressure of 14.7 psi (at sea level) will push the mercury to a height of 29.9 inches. Less pressure will raise the mercury in a less amount. The ratio is 1 pound of pressure for every 2 inches rise in a column of mercury. At an elevation of 6000 feet the atmospheric pressure of 11.7 psi will push the mercury column to 26.9 inches. See illustration on page 37.

Select the following statement(s) that is/are true.

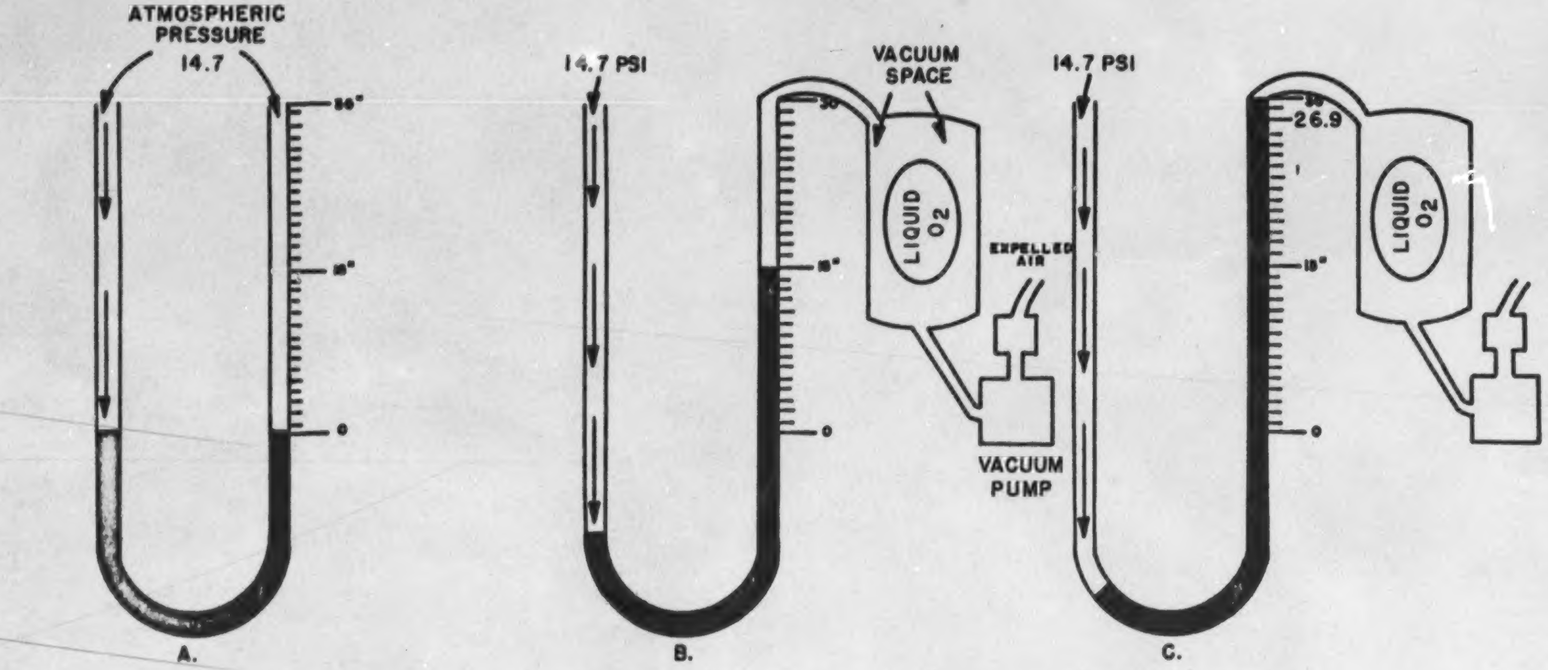
_____1. Atmospheric pressure becomes higher above sea level.

_____2. Pressure less than atmospheric pressure is a partial vacuum.

_____3. A mercury barometer is used to measure a partial vacuum.


SEA LEVEL ATMOSPHERIC PRESSURE 14.7 PSI
ABSOLUTE PRESSURE SEALED BY MERCURY COLUMN
30 29 28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
29.9
NORMAL BAROMETRIC PRESSURE READING AT SEA LEVEL
ATMOSPHERIC PRESSURE AT CHEYENNE, WYO. ELV. 6000 FT.
11.7 PSI
ABSOLUTE PRESSURE SEALED BY MERCURY COLUMN
30 29 28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
29.9
26.9
NORMAL BAROMETRIC PRESSURE READING AT CHEYENNE, WYO.

Barometer Used to Measure Atmospheric Pressure.


ATMOSPHERIC PRESSURE
14.7
30"
15"
0
14.7 PSI
VACUUM SPACE
30
15"
0
LIQUID O_2
EXPELLED AIR
VACUUM PUMP
14.7 PSI
30
26.9
15"
0
LIQUID O_2

A.

MANOMETER ZEROED WITH PRESSURE EQUAL ON BOTH SIDES.

B.

AFTER A SHORT TIME OF VACUUM PUMP OPERATION.

C.

AFTER CONSIDERABLE OPERATION OF THE VACUUM PUMP.

Operation of a Manometer.

2889

Answers to Frame 23: 1. ____ 2. T 3. T

Frame 24

MEASUREMENT OF VACUUMS

One method used to show the degree of vacuum is based on the measurement of inches of mercury. A manometer can be used for this. The difference in the operation of a barometer is that a manometer will use atmospheric pressure as a known pressure and a partial vacuum as the unknown, illustration on page 38. Note in Example "A" that the mercury level will be equal in each side of the U tube (manometer) when both ends of the tube are open to atmospheric pressure. By connecting one side of the manometer tube to a vacuum space (the annular space of the tank) and then pump a vacuum in that space, the mercury level in the manometer will change, Example "B". Atmospheric pressure on the open end of the manometer tube will force the mercury up the tube connected to the partial vacuum. The mercury will rise in the direction proportional to the degree of vacuum that has been created by the pump. Examples B and C.

NO RESPONSE REQUIRED.

273

Answers to Frame 24: NO RESPONSE REQUIRED

Frame 25

A vacuum of 28.9 inches of mercury is a high vacuum. But, in the annular space of a LOX tank, such a vacuum is still not high enough for storing liquid oxygen. The vacuum in the annular space should be as close as possible to a perfect vacuum (the absence of all pressure). The manometer is a good instrument for measuring a vacuum to a tenth of an inch. But for measuring the vacuum in a LOX storage tank this is not good enough. To split vacuum readings in small increments less than tenths, the metric system is used. This unit of measurement is the micron. In C of the figure shown on page 38 the vacuum pump has pumped a low pressure or vacuum, equal to nearly 30 inches of mercury. As shown, the exact measurement is hard to determine. This is why a micron scale is used for measuring the vacuum in a LOX tank. One inch of mercury is equal to 25,400 microns; thus, the distance between 28.9 and 29.9 inches of mercury is equal to 25,400 microns. The micron scale shows the increments so the exact degree of vacuum can be seen. Instead of a manometer, the degree of vacuum in a LOX tank is determined by a vacuum gage with a micron scale.

Select the following statement(s) that is/are true.

_____1. A manometer uses partial vacuum as a known pressure.

_____2. Vacuum readings need to be divided into smaller readings than tenths.

2891

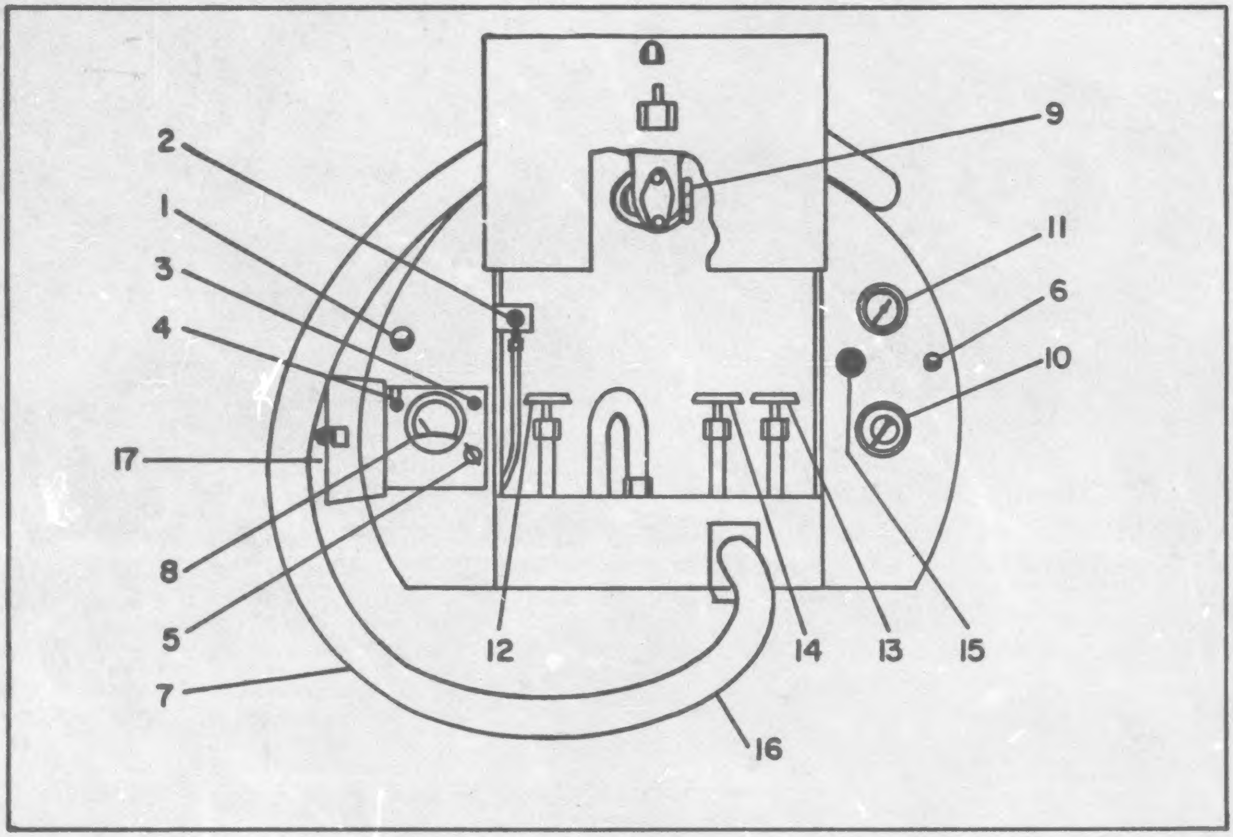
Answers to Frame 25: _____1. __T__ 2.

Frame 26

MICRON GAGES

The micron gage (vacuum gage) on LOX Storage Tanks indicates the vacuum in the annular space. Its scale is from 0 to 1000 microns. On the micron scale the less the reading, the greater the vacuum. As we said before, the greater the vacuum in the annular space the more difficult it is for heat to move by convection. So the greater the vacuum in the annular space of a LOX TANK the more efficient it is for storing LOX.

NO RESPONSE REQUIRED



1. Pressure Relief Valve I
2. Purging Device
3. Button
4. Button or Switch
5. Knob
6. Pressure Relief Valve 6
7. Transfer Hose
8. Thermocouple Vacuum Gage
9. Vacuum Valve A
10. Capacity Gage
11. Pressure Gage
12. Vent Valve E
13. Pressure Build-Up Valve D
14. Fill-Drain Valve C
15. Capacity Gage Valve B
16. Transfer Hose
17. Vacuum Gage Assembly

Micron Gage.

2893

Frame 27

When a 50 or 500 gallon tank is cooled down (has LOX in the inner tank) the vacuum in the annular space must be less than 250 microns. 2,000 or 5,000 gallon tanks must have a vacuum of 100 microns or less. Anytime the vacuum reading is more than that specified for storing LOX, the tank should be taken out of service. Check for leaks and recheck the vacuum holding capabilities. If there is not a vacuum in the annular space loss of LOX will result by evaporation. The micron gage (vacuum gage) is easy to use. It is a thermocouple tube and is on the panel of the tank control hood. To take a reading, place the toggle switch (4 on page 42) in the "on" position. While the switch is in the "on" position the needle of the gage 8 on page 42 should read zero. If the needle does not return to zero, adjust the black knob (5 on page 42 while pressing the contact button (switch 3 on page 42). Adjusting the potentiometer should make the gage needle return to zero. After the needle has been zeroed, release the contact button. The gage should now show the degree of vacuum.

Complete the following statements by filling in the blanks.

1. After a 50 gallon tank has cooled down, the vacuum should be

   less than ______ microns.

2. Without a vacuum in the annular space, loss of LOX will result by

   ______________.

3. The micron gage is a ____________ tube.

2894

Answers to Frame 27: 1. 250 2. evaporation 3. thermocouple

Frame 28

REVIEW OF LOX STORAGE TANKS

Tanks for the storage and handling of LOX are made in many sizes. They range in size from small Dewar flasks (thermos bottles) for lab use to tanks with a capacity of many thousands of gallons for missile support. There are several different types of tanks used for storage and handling of LOX. A 50 gallon tank, mounted on a four-wheel trailer, is used to service aircraft. Other tanks have capacities of 500-, 2000-, and 5000 gallons. These are skid mounted and used for storage and transfer. All of these LOX Storage Tanks are constructed of two concentric cylinders, separated by the annular space. This space is filled with insulation, note page 45.

The temperature of liquid oxygen within tank is -297°F. Even so, there is a slight boiling at all times due to some heat transfer. This slight boiling governs the evaporation rate or liquid loss. The evaporation rate, by volume for every 24 hours with a full tank should not exceed:

Type MA-1 (50 gal)	3.0%
Type C-1 (500 gal)	1.0%

No specified boiloff rates are given for the 2000 or 5000 gallon LOX storage tanks.

The tanks have piping, valves and gages used in operation. All of this equipment is accessible in the tank control hood as shown on page 45. A fill-drain line and a vent line connect the external piping to the inner tank, (items 17 and 19). The fill-drain lines contain porous filters which take out foreign particles from the final product. The vent line vents the inner tank to the atmosphere during normal storage. A pressure buildup coil (item 2) is connected between the vent and fill-drain lines. This coil acts as a heat exchanger and picks up heat to evaporate some liquid to pressurize the inner tank for liquid transfer. A vacuum line is connected to the annular space near the top of the storage tank. This line is used to evacuate the air in the annular space (item 7) page 45.

Select the following statement(s) that is/are true:

_____1. 50-gallon tanks are used to service aircraft.

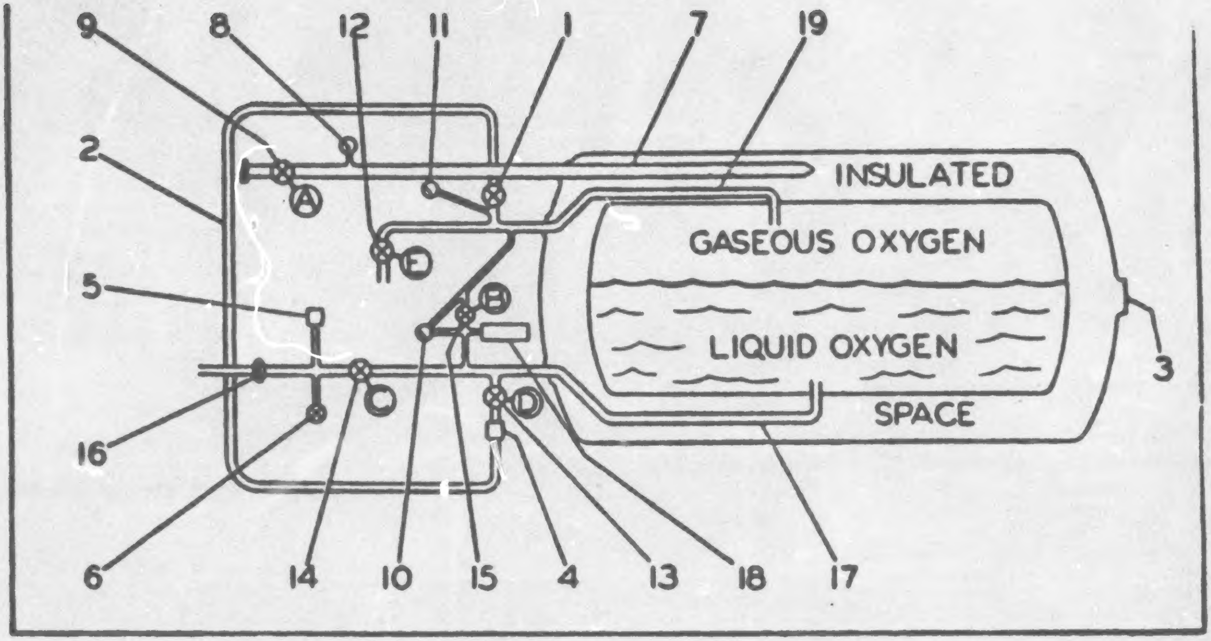
_____2. All LOX storage tanks are made with two concentric cylinders.

_____3. Temperature of liquid oxygen within a tank is -297°F.

_____4. The fill-drain line is used to fill or drain the inner tank.

_____5. The pressure buildup coil is connected between the vent and fill-drain lines.

_____6. The vacuum line evacuates air in the annular space.


9
8
12
11
1
7
19
2
INSULATED
A
E
GASEOUS OXYGEN
5
B
LIQUID OXYGEN
3
C
D
SPACE
16
6
14
10
15
4
13
18
17

1. Pressure Relief Valve 1
2. Pressure Buildup Coil
3. Rupture Disc
4. Safety Disc
5. Safety Disc
6. Relief Valve 6
7. Vacuum Line
8. Thermocouple Vacuum Gage
9. Vacuum Valve A
10. Capacity Gage
11. Pressure Gage
12. Vent Valve E
13. Pressure Buildup Valve D
14. Fill-Drain Valve C
15. Capacity Gage Valve B
16. Filter
17. Fill-Drain Line
18. Dampener Tank
19. Vent Line

Liquid Oxygen Cryotainer.

2896

Answers to Frame 28: 1. T 2. T 3. T 4. T 5. T 6. T

Frame 29

GAGES

Conveniently located on the LOX Storage Tank control hood are three gages: The inner tank pressure gage, a capacity gage, and the vacuum gage, page 45. The purpose of the vacuum gage (micron) indicates the vacuum in the annular space. The pressure gage indicates the pressure inside the inner tank when it is built up for the purpose of transferring liquid. It gives a reading in pounds per square inch. The capacity gage indicates the amount of liquid in a LOX Storage Tank.

NO RESPONSE REQUIRED

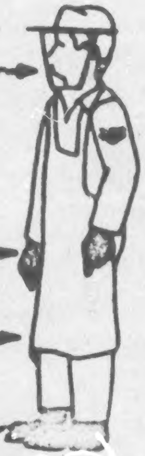
Answers to Frame 29: NO RESPONSE REQUIRED

Frame 30

SAFETY

Carelessness in handling cryogenic fluids can result is bodily injury or damage to equipment. The extremely low temperatures can cause severe frostbite (burns) if allowed to contact human skin. High-purity oxygen greatly increases the potential for supporting combustion. Oxygen vapors mixed with such fuels as diesel fuel, tar, rags, or clothing can cause an explosion if ignited. There are many sources of ignition which can result in an explosion. A few of these sources are an open flame, lighted cigarettes, matches, static electricity, or scraping shoe nails against a concrete floor. Always wear tightly woven cotton clothing whenever working with liquid oxygen. Do not wear woolen or nylon clothing because there is danger of static sparks caused by this material. Wear high-top shoes with sewn soles (no nails). Wear your trouser legs outside shoe tops to prevent spilling liquid into your shoes. Note in the sketch what we are talking about. In addition, wear a face shield, loose fitting heavy degreased gauntlet gloves, and a long rubberized or asbestos apron.

These protective devices are mandatory when handling liquid oxygen. Smoking or any other source of ignition must not be allowed within 50 feet of the area where liquid oxygen is handled or stored. Also do not smoke for at least 30 minutes after handling liquid oxygen. Clothing saturated with oxygen vapor could explode with a flash while lighting a cigarette. Provide adequate ventilation in areas where liquid oxygen is handled and stored. It is necessary to ground oxygen tanks during transfer and storage. Keep oil and grease, and any hydrocarbons away from an area where liquid oxygen is stored or transferred. Do not allow equipment to become contaminated. Cleanliness of person, clothing, and equipment is a necessity.



The face shield must cover the entire face.

The cuffs of the asbestos gloves must be tucked inside the sleeves of your uniform to prevent spills from running down inside the gloves.

The apron must cover the body at least down to the knees. It can be longer.

Shoes must be laced tightly and rubber boots may be worn as additional foot protection. Trouser cuffs must cover the tops of the shoes or boots.

2898

Frame 30 (Cont'd)

Complete the following statements by filling in the word or words needed to finish the statement.

1. The protective devices which are mandatory when handling liquid oxygen are a long ______________ ______, loose fitting ___________ _______ and a _______ __________.
2. Oxygen vapors mixed with ____ ______ or ______ can cause an explosion if ignited.
3. Always wear tightly woven _________ clothing whenever working with liquid oxygen.
4. It is necessary to _______ oxygen tanks during transfer and storage.

2899

Answers to Frame 30: 1. rubberized apron, gauntlet gloves, face shield
2. diesel fuel, tar 3. cotton 4. ground

Frame 31

Review Exercise

The following questions are to help summarize the material which has been presented in the preceding text. If you cannot answer the questions refer to the frame numbers at the end of the questions.

1. What are three ways in which heat can be transferred? (Frames 20, 21, 22)
2. Where is the annular space located in liquid oxygen storage tanks? (Frame 19)
3. What gages are located on the cryotainer hood? (Frame 29)
4. Define a perfect vacuum and explain how a vacuum is used to prevent vaporization. (Frame 23)
5. What type of gage is used to measure the vacuum in the annular space? (Frame 24)
6. When the tank is cool, how many microns are allowed in the annular space? (Frame 25)
7. What are the four types and sizes of storage tanks used with oxygen/nitrogen plants? (Frame 28)
8. Describe the capacity gage and its use. (Frame 29)
9. What safety devices are installed in the storage tanks to prevent excessive pressure? (Frames 6 and 7)
10. Why do the three main control valves have extended stems? (Frame 2)

2900

Frame 32

From the following list of cryotainer components, match the function/operation to the numbered component.

_____1. Pressure gage

_____2. Filler valve

_____3. Transfer hose

_____4. Rupture disc

_____5. Pressure buildup valve

_____6. Capacity gage

_____7. Fill/drain valve

_____8. Vent valve

a. For moving liquid from one tank to another.

b. Used to buildup pressure in the tank when needed to transfer.

c. Measures pressure buildup within the tank caused by vaporizing LOX.

d. Shows the amount of liquid oxygen in the tank.

e. To release pressure in the inner tank and hose.

f. Opened by 30 psi pressure from the LOX tank.

g. To fill or drain liquid from the tank.

h. Lets pressure out of the tank.

i. Breaks when pressure in the annular space reaches 30 psig.

j. Breaks if the pop-safety valve fails to open.

2901

Answers to Frame 32: c 1. f 2. a 3. i 4.
b 5. d 6. g 7. h 8.

INSPECTION, MAINTENANCE AND OPERATIONAL PROCEDURES OF LOX EQUIPMENT

INTRODUCTION

In the first 32 frames we learned how the cryotainers were built. In these next frames we will learn how to maintain the parts which make up the cryotainer system. Methods of purging a contaminated storage tank will be explained. Operation of the vacuum pumps will be discussed and operator maintenance which will be required as well as a troubleshooting chart. All of these are necessary if we are to keep the equipment in the best possible condition for a long period of time.

Frame 33

Cleaning and Degreasing Liquid Oxygen Tanks

After the inner tank or inner lines of a storage tank have been repaired they may have a residue of flux, dirt, or oxidation. Cleaning, if required, is usually done by depot or contractor personnel. Normally, an organization does not have the equipment to degrease and clean the tank. Even though you may only help clean a tank you should know how it is done.

Procedures for Cleaning and Degreasing

Note: Before cleaning and degreasing the inner tank and lines of a storage tank, the tank must be drained, purged and warmed. Refer to TO 37A12-1-101 for specific procedures.

Complete the following statement.

1. The tank must be __________, __________, and __________ before cleaning and degreasing.

2907

Answers to Frame 33: drained, purged, and warmed

Frame 34

The inner tank is cleaned with a degreasing solvent and trichloroethylene,. A degreasing machine is connected to the vent line of the tank. The tank fill/drain valve is closed and its vent valve is open. The degreaser pumps a degreasing solvent into the inner tank. The vapors from the degreasing solvent forms on the inner surface of the tank, washing any contaminants to the bottom. The pumping continues until the vapor pressure within the tank reaches 30 psig. The degreasing machine is then disconnected from the tank and the vent valve on the tank remains open. Then trichloroethylene is pumped into the tank through the fill/drain line. With the cleaning solvent in the tank, the tank must be agitated. Slings are placed on the tank and it is lifted with a crane. The crane operator shakes the tank from end to end and side to side, then lowers it so the cleaning solvent can be removed. The tank is pressurized through the vent line with 30 psig of gaseous nitrogen. Then the fill/drain valve is rapidly opened to remove the solvent and residue. The above cleaning procedures are repeated to insure the inner tank is clean. The tank is then purged with the GSU-62/M purging unit to remove all traces of the vaporous degreasing solvent and cleaning solvent.

Select the following statement(s) that is/are true.

_____1. The tank is pressurized with 30 psig of gaseous nitrogen.

_____2. Trichloroethylene is pumped into the tank through the buildup valve.

_____3. The tank is agitated once the cleaning solvent is inside.

Answers to Frame 34: 1. T 2. T 3. T

Frame 35

INSPECTION OF STORAGE TANKS

Storage tanks operate under field conditions for long periods of time without major overhaul unless they are damaged through carelessness or accidents. The correct operation of the storage tank is the most important factor concerning safety and the storage of liquids. To maintain the tank in the best possible operational condition at all times, the following are checked as often as indicated:

1. Vacuum assembly. (Monthly)

2. Batteries (power supply for vacuum gage assembly). (Weekly) (Check for corrosion.)

3. Pressure relief valves. (Check as necesary by building up pressure in the cryotainer as specified in the TO.)

4. Outer shell rupture disc. (Weekly)

5. Filter container. (Before use.) (Monthly, remove and clean with trichloroethylene.)

6. Hose transfer. (Before use; visually inspect.) (Also, once a month, pressurize with nitrogen or oxygen and leave overnight.)

7. Vacuum gage. (As necessary.) (At least weekly check the operation and microns of vacuum.)

8. Capacity gage. (As necessary.) (At least weekly check the reading and operation.)

9. Lines and valves. (Check daily for leaks.) (Visually inspect while under pressure.)

10. Pressure buildup gage. (Each time used or at least weekly.) (Check the operation.)

11. Valves (PBU, vent, fill/drain). (Daily). (Visually inspect and pressure test for leaks.)

12. Pressure buildup coil. (Weekly) (Visually inspect and pressure test for leaks.)

13. Container. (Monthly) (Visually check for damage.)

14. Safety disc (vent and PBU). (Monthly) (Check for an accumulation of moisture and dirt.)

Frame 35 (Cont'd)

Select the following statement(s) that is/are true.

_____1. Correct operation of storage tanks is an important factor concerning safety and storage of liquid oxygen.

_____2. Major overhauls must be accomplished very frequently.

_____3. The pressure relief valves are checked by building up pressure according to the TO.

Answers to Frame 35: __T__ 1. _____2. __T__ 3.

Frame 36

Most of the above checks are made without disassembling the storage tank, but occasionally the hood assembly has to be removed. When disassembling the hood assembly make sure all the liquid oxygen has been removed from the tank. Removing the liquid oxygen and allowing the inner tank to warm up provides for safe working conditions. Use the proper tools to perform all maintenance. Always handle component parts and assemblies with extreme care to prevent creating new troubles. After disassembling, all parts that contact the liquid oxygen must be cleaned with trichloroethylene before they are replaced. DO NOT touch them with your hands; use clean gloves because the human skin contains oils which rub off on what you touch. When assembling component parts, use Teflon tape to seal each connection. Teflon tape does not react with liquid oxygen. All valve gaskets that have been removed must be replaced with new Teflon gaskets.

Select the following statement(s) that is/are true.

_____1. Clean gloves must be used when handling parts that contact LOX.

_____2. The hood assembly may be disassembled with LOX in the tank.

_____3. During maintenance Teflon tape is used to seal each connection.

_____4. Gaskets may be reused depending upon their condition.

2906

Answers to Frame 36: T 1. ___2. T 3. T 4.

Frame 37

TESTING STORAGE TANKS FOR LEAKS

To test for leaks, pressurize the warm tank with dry oil-free air or N_2 gas. Never exceed the maximum pressure specified in the applicable TO for the tank. With the tank pressurized, use a brush to completely coat all seams and connections with an approved oxygen leak test liquid soap. If there is a leak, bubbles will appear wherever the soap solution has been applied. To repair a leak, first release the pressure and then eliminate the leak by tightening, repairing, or replacing the faulty fittings. Repressurize the tank and then apply another coat of the leak test solution to make certain that the leak has been eliminated. If an approved oxygen leak test liquid soap is not available, a liquid solution made with water and ivory or castile soap can be used. These soaps are oil-free and safe for oxygen equipment. This type of solution is used in the same way as the preferred oxygen leak test solution. After the testing has been completed, use trichloroethylene to remove all traces of the testing solution from the equipment. While repairing any leak make sure that the equipment does not become contaminated with oil or grease.

Select the following statement(s) that is/are true.

_____1. Nitrogen is used to test tanks for leaks.

_____2. Any type leak test solution may be used.

_____3. To repair a leak all pressure must be released.

_____4. After testing, the tank must be cleaned with trichloroethylene.

Answers to Frame 37: T 1. ____ 2. T 3. T 4.

Frame 38

SERVICING THE PRESSURE GAGE

The pressure gage, shown in figure on bottom of page 74, measures the pressure buildup within the tank which is caused by the "vaporizing" of the liquid oxygen in the pressure buildup coil. The gage is located in the vent line which prevents liquid oxygen from reaching the gage. It measures the gas pressure in pounds per square inch and will not measure liquid pressure. This gage is one of the most important instruments to the operator, especially when transferring liquid. Air Force specifications require a pressure of approximately 30 psi for most transfers. The tank pressure should never be allowed to build up higher than 30 psi.

> Note: If for some reason the gage does not work and the pop-safety valve and the safety disc are not working properly because of frozen moisture or dirt, the tank could build up sufficient pressure to rupture itself. Such a rupture would cause a great deal of equipment damage, severe injury, or fatalities.

Complete the following statements by filling in the blanks.

1. Pressure buildup within the container caused by vaporizing liquid oxygen is measured by the ________ ________.
2. To prevent liquid oxygen from reaching the pressure gage, the gage is located in the _____ ______.
3. When transferring liquid oxygen, the tank pressure should never exceed ___ _____.

2908

Answers to Frame 38: 1. pressure gage 2. vent line 3. 30 psi

Frame 39

A defective pressure gage can measure either low or high. If the gage measures high, there will be insufficient pressure to transfer the liquid. In case the gage measures low, the pressure can exceed the normal transfer pressure of 30 psi, causing the pop-safety valve to operate or the safety disc to rupture. Under no circumstance should the pressure in the tank exceed 45 ± 5 psi, the pressure needed to operate the pop-safety valve. You can detect a faulty gage while making a transfer or by the operation of the safety valve. If you determine that the pressure gage is defective, replace the complete gage assembly immediately.

Select the following statement(s) that is/are true.

_____1. A defective pressure gage can measure either high or low.

_____2. The tank pressure should never exceed 45 ± 5 psi.

_____3. If the gage is determined to be defective, replace the complete gage assembly.

Answers to Frame 39: __T__ 1. __T__ 2. __T__ 3.

2909

Frame 40

SERVICING THE CAPACITY GAGE

The capacity gage, shown in figure on bottom of page 74, operates the same as the bellows used by a blacksmith. As the pressure goes up on the bellows, the needle of the gage moves toward maximum. The operation of the gage is all mechanical, using the pressure caused by the weight of the LOX in the tank to expand the bellows of the gage. Movement of the bellows moves the needle, in reference to the pressure on the second bellows, to show the amount of LOX in the tank.

A defective capacity gage will show no measurement, or indicate a smaller quantity than is stored in the tank. To replace a defective gage, remove the complete gage assembly. The letters P (liquid side) and S (gas side) on the back of the gage indicates how the gage assembly is to be installed, shown in figure on bottom of page 74. If the gage is not correctly installed, it will become damaged or give a wrong reading of the liquid oxygen in the tank.

Fill in the blanks to complete the following statements.

1. As the pressure goes up on the ________, the _______ of the gage moves toward _______.

2. To replace a defective capacity gage, the complete assembly must be _________.

3. If the gage is installed incorrectly, it will give a ______ ______ of the liquid oxygen in the tank.

2910

Answers for Frame 40: 1. bellows, needle, maximum 2. removed
3. wrong reading

Frame 41

The capacity gage is a sensitive differential pressure gage. It is protected by the surge tank which reduces the surging of gas or liquids within the gage lines. An added feature that protects the gage from high-pressure surges are the .013 inch orifices which reduce the high pressure entering the gage.

When transferring liquid oxygen the capacity gage bypass valve is always open. This is to protect the capacity gage from high pressure and sudden surges during the transferring operations. When transferring, the liquid oxygen is boiling, thus it induces a great disturbance within the tank. If the capacity gage bypass valve were closed, this disturbance would damage the gage.

Select the following statement(s) that is/are true.

_____1. The capacity gage bypass valve is closed when transferring liquid.

_____2. The surge tank protects the buildup system from sudden pressure changes.

_____3. The capacity gage is a sensitive differential pressure gage.

_____4. Orifice size has a definite bearing on the gage's operation.

2911

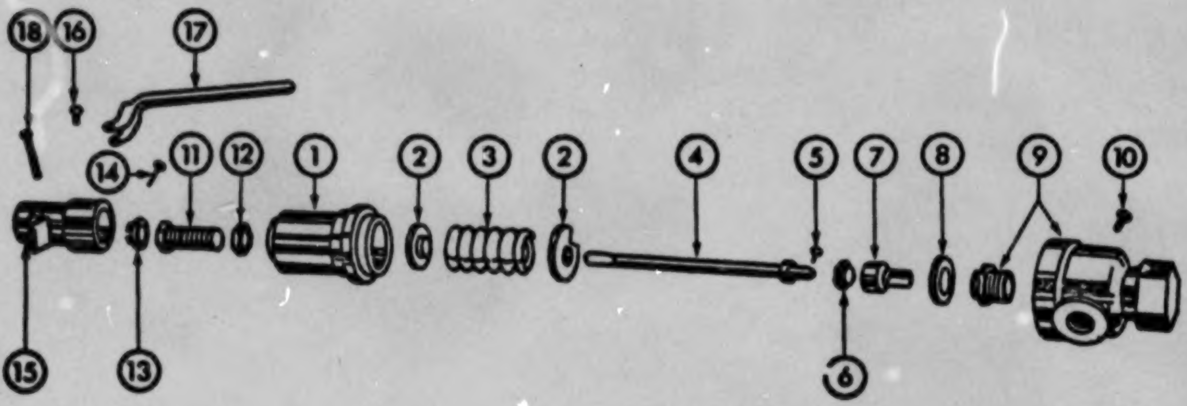
Answers to Frame 41: ____1. ____2. __T__3. __T__4.

Frame 42

ADJUSTING THE POP-SAFETY VALVE

The pop-safety valve is set to open at 45 ± 5 psi and protects the equipment and operator. This type of valve can be adjusted to operate at the correct pressure if necessary. If an adjustment is required, the valve is installed in a test stand. If a test stand is not available, the pressure test can be performed by connecting the valve to a compressed air source of 45 ± 5 psi.

Caution: Use a calibrated air pressure gage to determine the pressure of the air source.



1. Cover - valve
2. Washer - valve spring
3. Spring
4. Stem
5. Pin
6. Nut - star
7. Star disk
8. Ring volume adjusting
9. Base assembly and sept
10. Screw - lock adjusting ring
11. Screw - pressure adjusting
12. Nut - lock pressure adjusting
13. Nut - valve stem (some cases 2 each instead of pin cutter #14)
14. Pin - Cotter
15. Cap
16. Screw - cap holding
17. Lever - manual release
18. Pin - lever to cap

Pop-Safety Valve.

Select the following statement(s) that is/are true.

____1. The pop-safety valve protects the equipment and the operator.

____2. To adjust the valve, it is installed in a test stand or connected to a compressed air source of 45 ± 5 psi.

2912

Answers to Frame 42: _T_ 1. _T_ 2.

Frame 43

To adjust the valve, remove the cap and lever (15 and 17, Frame 42) from the valve to expose the pressure adjusting screw (11, Frame 42). Slowly turn this screw to increase the pressure on the valve to the popping pressure of 45 ± 5 psi. Adjust the pressure adjusting screw (11, Frame 42) until the air pressure on the lower part of the disc is slightly more than the spring tension which holds the disc on its seat. When this point is reached, the air pressure will force the disc off of its seat. This will cause the valve to pop. Check the valve to make certain that it pops at the correct pressure. Tighten the nut and replace the cap and lever. Be sure to clean the valve assembly in trichloroethylene and replace it as a complete assembly. After replacing the pop safety valve, test the tank for leaks with compressed air and an approved liquid soap solution.

Select the following statement(s) that is/are true.

_____1. When air pressure forces the disc off its seat the valve will pop.

_____2. The popping pressure of the pop-safety valve is 45 ± 5 psi.

_____3. The valve must be cleaned with soap solution prior to reinstallation.

_____4. An operational check of the valve is required after adjustment.

_____5. After installation on the tank a leak check is required using an approved soap solution.

2913

Answers to Frame 43: _T_ 1. _T_ 2. ____ 3. _T_ 4. _T_ 5.

Frame 44

There are two foil discs on most cryotainers. These are called safety discs, and are in the lines in parallel with the pop-safety valves. If the pop-safety valves fail to open or cannot get rid of the pressure fast enough, the discs will break and help to vent the pressure.

Most tanks have a third disc, called a rupture disc, which breaks at 30 psig. If a leak should develop in the inner tank, liquid will escape into the annular space, gassing off and building pressure in the space between the tanks.

Fill in the blanks to make a complete statement.

1. The safety device which is in the line in parallel with the pop-safety valve is the ________ _______.
2. The rupture disc will break at _____ psig.
3. The safety disc will break if the pop-safety valve fails to _____.

2914

Answers to Frame 44: 1. safety disc 2. 30 3. open

Frame 45

SERVICING THE FILLER VALVE

The filler valve is located on the hose assembly that is used to transfer liquid oxygen from the LOX tank to the aircraft. Before liquid oxygen can be transferred to an aircraft the hose is connected to the LOX tank. Then the hose assembly is purged by opening the LOX tank fill/drain valve. When the female connector is plugged in the aircraft, the liquid oxygen begins to flow from the LOX tank. The pressure (30 psi) in the LOX tank will cause the liquid oxygen to flow by exerting sufficient pressure on the filler valve to open it. Often the filler valve will leak or freeze. This valve must be very closely checked to see if it functions properly. A filler valve that leaks will cause a loss of liquid oxygen, which is a safety hazard to operators. Do not use force to disconnect a frozen valve from the aircraft. This can cause damage to the filler valve. In case the valve is frozen, it can be thawed with water or by the ambient air, providing the flow of liquid oxygen is stopped for a short time. To stop the flow of liquid oxygen the operator must close the fill/drain valve and relieve the pressure from the hose by operating the hose pressure relief valve. Refer to illustration on page 65 figure 5, for an illustration of a filler valve.

Select the following statement(s) that is/are true.

_____1. The transfer hose must be purged prior to aircraft servicing.

_____2. The servicing valves seldom leak.

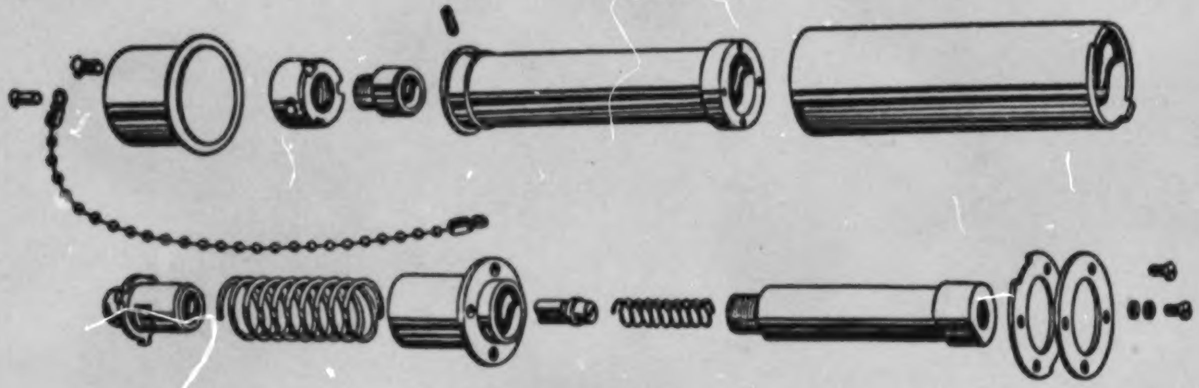
_____3. Servicing valves should never be forced onto filler valves.

_____4. Pressure must be relieved from the hose after servicing operations are complete.

Answers to Frame 45: T 1. ___ 2. T 3. T 4.

Frame 46

The second common trouble is leaks between the disc and seat. When this is known install a new valve. A valve that has a damaged disc or seat is detected by a leak in the lines, thus the lines will frost. Liquid loss in the LOX storage tanks should be limited to evaporation, some spillage, and gas out through the vent line.



Filler Valve.

Complete the following statements by filling in the blanks.

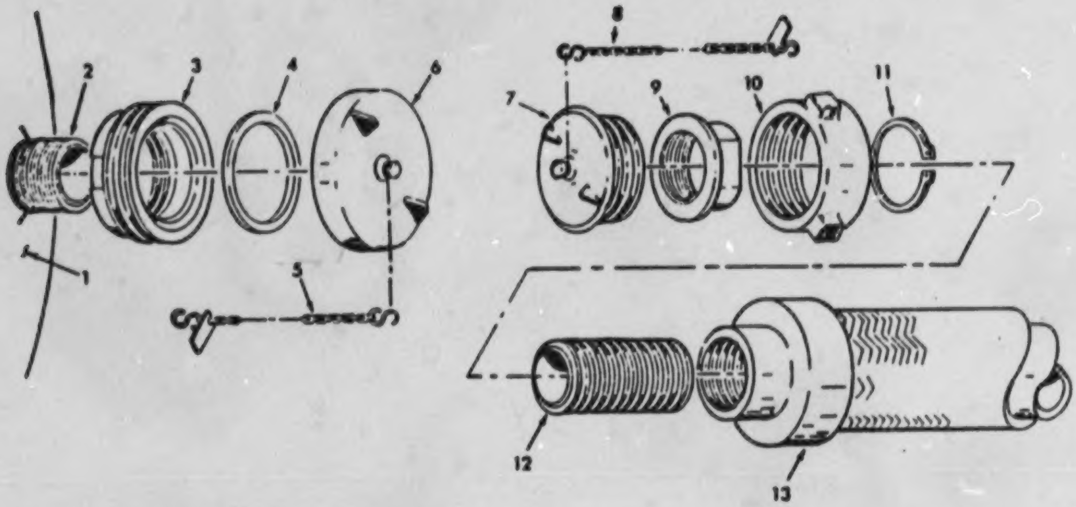
1. Another common trouble with the filler valve is ________ between the _______ and ________.
2. A leak in a line is detected by __________ on the line.
3. Liquid loss in the storage tank should be limited to ____________, some _________, and gas out the ______ line.

Answers to Frame 46: 1. Leaks, disc, seat 2. frost
2. evaporation, spillage, vent

Frame 47

SERVICING THE HOSE ASSEMBLY

The tank and servicing hose couplings are made to hold the pressure and temperature, and slow down the loss of liquid oxygen through transfer and handling. Check the ends of the hose for foreign material before each transfer. Do not drag the hose assembly or run over it with any vehicle. Both of these will break or damage the hose. This will cause it to leak. Leaks can be found by frost spots on the outside of the hose. The transfer hose is for moving liquid from one tank to another.



Tank and Servicing Hose Couplings.

Select the following statement(s) that is/are true.

_____1. Frost spots on the outside of the hose indicates a leak.

_____2. The hose must not be dragged or run over with a vehicle.

_____3. The hoses are fairly durable and do not require special handling.

_____4. Hoses should be checked for FOD prior to use.

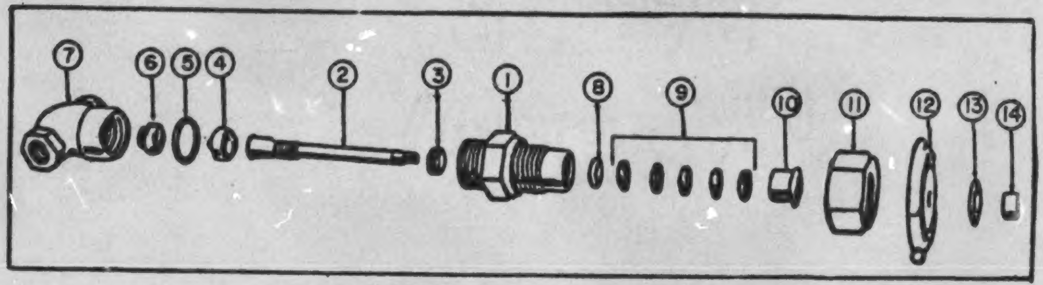
Answers to Frame 47: T 1. T 2. ____ 3. T 4.

2917

Frame 48

SERVICING THE VENT, PRESSURE BUILD-UP, AND FILL/DRAIN VALVES

These valves are all similar in design and are globe valves. Two troubles are common to globe valves; stem leakage and leakage between their discs and seats. The most likely trouble is the leakage between the stem and packing, which is easy to fix. Stem leakage occurs only while the valve is open because all globe valves are installed so that the pressure is against the seat and disc when the valve is closed. An arrow is often stamped on the valve body which shows the correct installation according to the direction of flow. Visually inspect the valve through its two openings before installation, this will also show you its correct installation according to the direction of flow. To stop the packing from leaking, torque the packing nut. If a valve is frozen from moisture, pour water over it to thaw it out.



1. Bonnet
2. Stem
3. Nut - Disc
4. Disc - Valve
5. Gasket
6. Seat - Valve
7. Body - Valve
8. Ring - Packing
9. Packing
10. Gland - Packing
11. Nut - Packing
12. Handwheel
13. Disc - Identification
14. Nut - Handwheel

Globe Valve.

> Caution: Do not torque the packing nut too much. If the leak does not stop under normal tension on the nut, remove the pressure from the system and remove the packing nut. Replace the old packing with a new teflon packing ring.

These valves are used for just what their names imply. The vent valve lets pressure out of the tank when it is no longer needed to transfer. The pressure buildup valve is used to build up pressure in the tank when needed for liquid transfer. The fill/drain valve is used to fill or drain liquid from the tank.

2918.

Frame 48 (Cont'd)

Select the following statement(s) that is/are true.

_____1. The most likely leaks on globe valves is between the stem and seats.

_____2. An arrow on the valve body indicates the direction of flow.

_____3. If the packing is leaking it must be replaced.

_____4. If the valve freezes, water may be used to thaw it out.

2419

Answers to Frame 48: __T__ 1. __T__ 2. __T__ 3. __T__ 4.

Frame 49

TROUBLESHOOTING

The method used to find the various troubles associated with liquid oxygen storage tanks is a systematic procedure of elimination. In order to use this method, it is important to know fully the operation of these tanks. Since troubles which occur with tanks are numerous, it is ncessary to refer to a troubleshooting chart, Table 1, pages 70 and 71. Study the various troubles, their probable cause, and remedies.

There are other malfunctions that may occur; but they are of a minor nature and will not affect the transfer, storage, or safety in handling of liquid oxygen. A small amount of mechanical ability and a little common sense will generally suffice to make necessary repairs, since the malfunction and the solution are generally quite obvious. For information about the procedures used in making the repairs or replacements indicated in the troubleshooting chart, refer to TO 37A12-1-101 which contains the repair instructions.

Select the following statement(s) that is/are true.

_____1. Troubleshooting storage tanks is a systematic process of elimination.

_____2. Troubleshooting charts are used to help you troubleshoot the system.

_____3. In order to troubleshoot, a thorough knowledge of the tank operation is required.

_____4. Repair instructions will be found in the applicable TO.

303

2920

Answers to Frame 49: T 1. T 2. T 3. T 4.

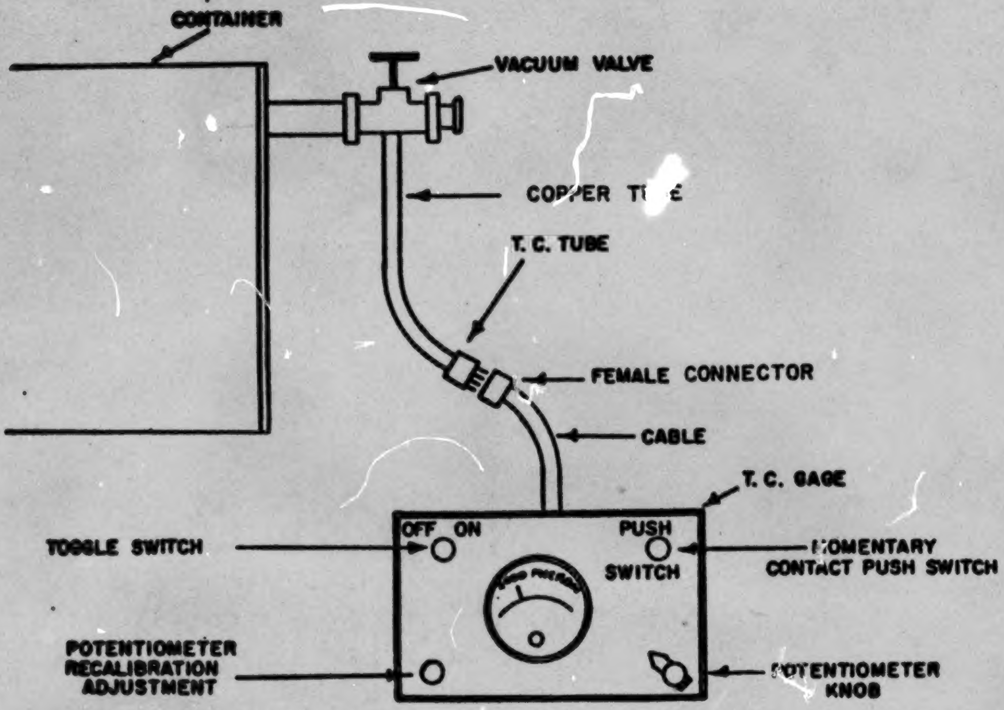
TROUBLE	PROBABLE CAUSE	REMEDY
Safety disc blows out below pressure setting	Defective pop safety valve	Replace
	Defective or kinked disc	Replace
	Defective gage	Replace
	Disc not centered	Replace
Malfunctioning of capacity gage	Valve stem leaks	Tighten or replace packing
	Unstable liquid condition	Wait
	Leak in gage line	Tighten connection
	Clogged line	Replace
	Defective gage	Replace
	Lines frozen or plugged	Thaw or clean
Pressure gage does not show any pressure	No pressure	Close vent and builoup valves
	Empty container	Fill
	Defective gage	Replace
	Plugged lines	Unplug
	Loose or leaky fittings	Tighten connection
	Needle valve loose	Repair or replace
Leaky transfer hose	Damaged	Replace hose
TC gage not reading (but you have a vacuum)	Batteries dead	Replace
	Loose electrical connections	Tighten
	Tube burned out	Replace
	Defective gage	Replace
Safety disc does not blow at prescribed pressure setting	Wrong size disc	Replace
Pressure relief valve (does not open at prescribed pressure setting	Frozen	Warm, work open
	Leak	Replace, adjust

Table 1. Troubleshooting Chart.

TROUBLE	PROBABLE CAUSE	REMEDY
Flow of liquid restricted	Foreign matter in hose	Purge, clean filters
	Defective fill/drain valve	Repair or replace
No pressure buildup	Vent valve open	Close valve
	Defective pressure gage	Replace gage
	Frosted coil	Warm up
	Insufficient LOX	Refill
	Safety disc ruptured	Replace
	Plugged lines	Unplug
	Leaks in lines and valves	Check fittings
Losing vacuum	Rupture disc blown	Replace
	Leak in weld	Reweld outer shell
	Defective gage	Replace
	Dirt in "O" ring grooves	Clean and replace rings
	Vacuum tube leaks	Replace
	Opened vacuum valve	Check safety wire
	Defective diaphragm on the vacuum valve	Replace
	Leak through rough edges of rupture disc	Cut foil, replace
	Gasket leak	Replace

Table 1. Troubleshooting Chart (continued).

2922
Frame 50


CONTAINER
VACUUM VALVE
COPPER TUBE
T. C. TUBE
FEMALE CONNECTOR
CABLE
T. C. GAGE
OFF ON
PUSH
SWITCH
TOGGLE SWITCH
MOMENTARY CONTACT PUSH SWITCH
POTENTIOMETER RECALIBRATION ADJUSTMENT
POTENTIOMETER KNOB

Thermocouple Gage and Tube.

SERVICING THE VACUUM GAGE ASSEMBLY

Turn on the toggle switch, figure above, push the momentary on switch and the gage should give a reading of zero. If the gage needle does not go to zero, adjust the potentiometer knob while pressing the momentary contact switch. Turn the potentiometer knob until the gage needle goes to zero. Then release the momentary contact switch and the gage should give the correct micron reading. If this adjustment does not cause the gage needle to return to the zero position, the batteries are probably dead. If the batteries are replaced or it is determined that they are in good condition, the TC (thermocouple) tube is probably defective. Replace the thermocouple tube by unplugging it from the female connector (the electrical cable connection to the gage). Now close the small diaphragm valve (vacuum valve) to prevent the loss of vacuum. With the valve closed, the thermocouple tube can be removed and replaced. Place teflon tape on the threaded connections, to prevent leakage, and replace the thermocouple tube to the female cable connector and gage cable. The gage should now operate properly. If not, the wiring within the cable may be defective. Diagram shown on top of page 73 is a complete wiring diagram and should be used to check for defective circuits.

2923

Select the following statement(s) that is/are true.

_____1. If the gage needle will not zero it must be replaced.

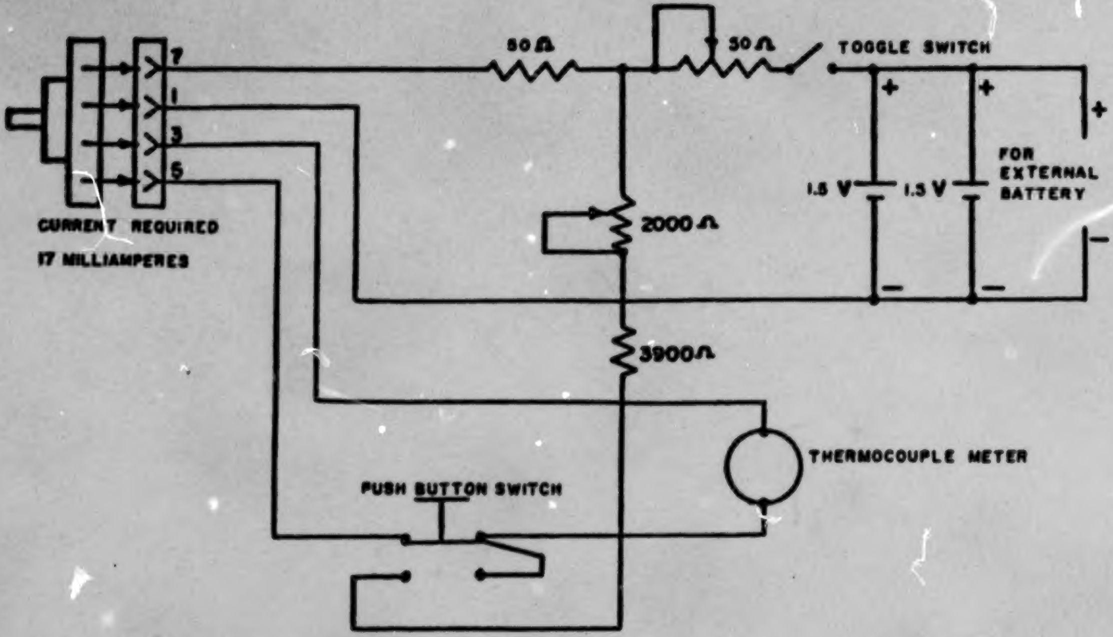
_____2. The vacuum valve must be closed to change the thermocouple.

_____3. The gage cannot be adjusted unless the momentary contact push switch is depressed.

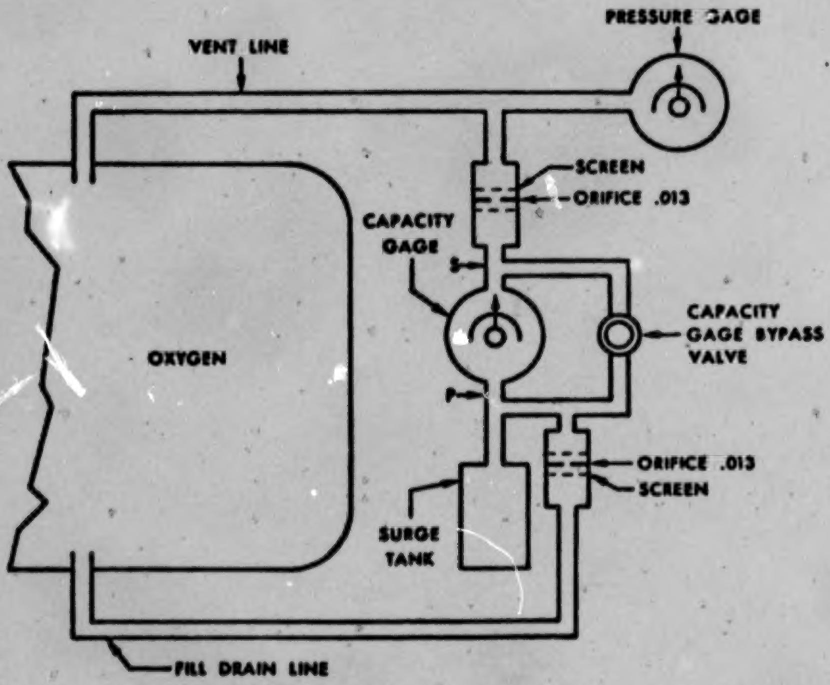
_____4. Teflon tape is required when replacing the thermocouple.

2924

Answers to Frame 50: ____ 1. T 2. T 3. T 4.


7
1
3
5
CURRENT REQUIRED
17 MILLIAMPERES
50 Ω
30 Ω
TOGGLE SWITCH
+
+
+
1.5 V
1.5 V
FOR EXTERNAL BATTERY
−
−
−
2000 Ω
3900 Ω
THERMOCOUPLE METER
PUSH BUTTON SWITCH

Thermocouple Wiring Diagram.

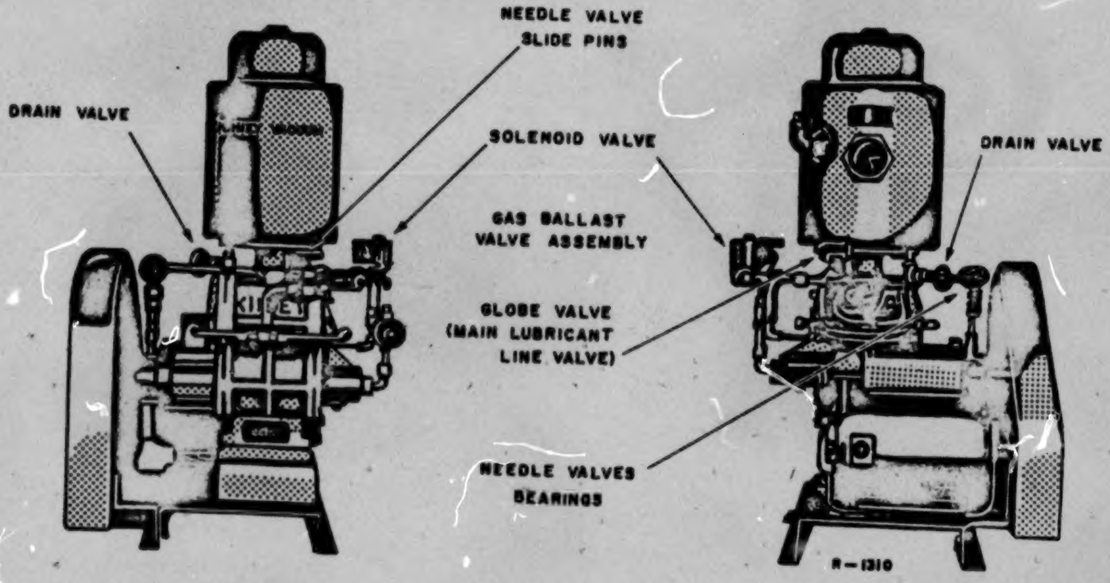

PRESSURE GAGE
VENT LINE
SCREEN
ORIFICE .013
CAPACITY GAGE
S
CAPACITY GAGE BYPASS VALVE
OXYGEN
P
ORIFICE .013
SCREEN
SURGE TANK
FILL DRAIN LINE

Differential Gage System.

PRINCIPLES OF OPERATION OF A VACUUM PUMP

The model KS-13 vacuum pump, illustration below, is an air-cooled, single stage, mechanical pump. The pump is designed to pump air out of the annular space of a LOX tank.

When pumping a vacuum the molecules of gas (air) in the annular space of the LOX tank must be removed. The air is pumped out by a high-vacuum pump. The term "high vacuum" is used rather loosely for pressures below 1mm (mercury). It can be said that high vacuum is the molecules of gas colliding more often with the wall of the tank than with each other. Pumps that are effective at ordinary pressures become inoperative with high vacuums. In a previous study guide, you should recall that a partial vacuum can be measured in inches of mercury by a barometer or manometer. To measure the small degree of pressure (vacuum) that is required for storing liquid oxygen a micron is used as the unit of measurement. (25,400 microns are 1 inch of mercury pressure.)


NEEDLE VALVE
SLIDE PINS
DRAIN VALVE
SOLENOID VALVE
DRAIN VALVE
GAS BALLAST
VALVE ASSEMBLY
GLOBE VALVE
(MAIN LUBRICANT
LINE VALVE)
NEEDLE VALVES
BEARINGS
R—1310

Model KS-13 High Vacuum Simplex Pumping Assembly Operating Valves.

Select the following statement(s) that is/are true.

____1. The KS-13 vacuum pump is used to evacuate the annular space between the inner and outer walls of the LOX tank.

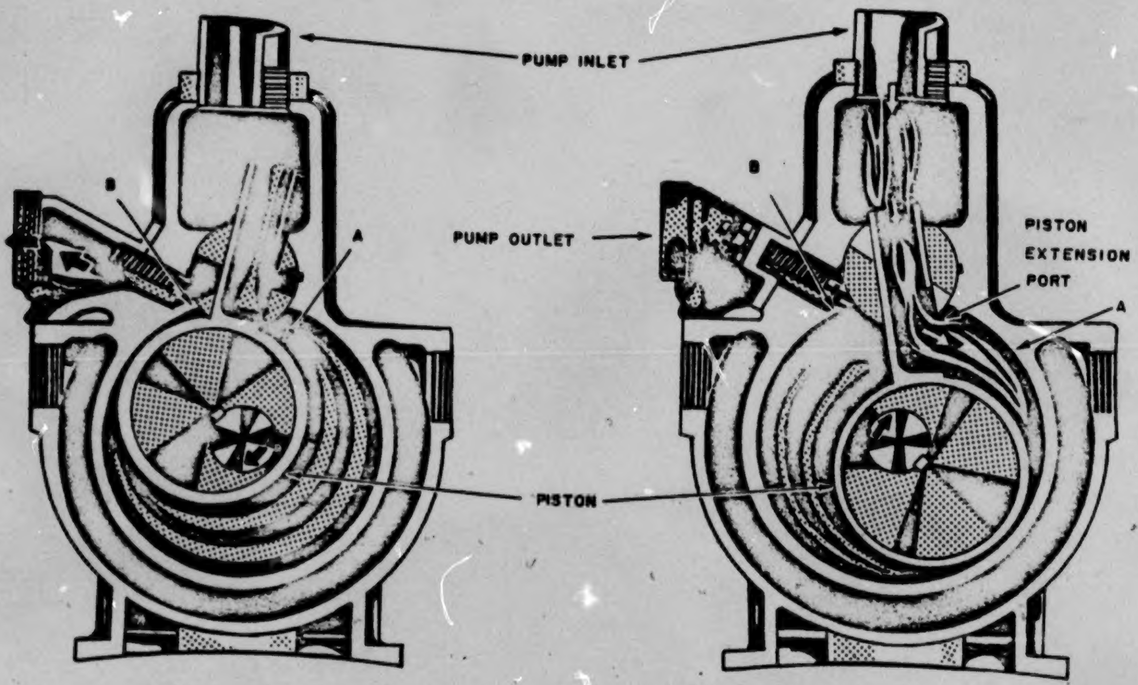
____2. Vacuum is measured in microns.

2926

Answers to Frame 51: T 1. T 2.

Frame 52

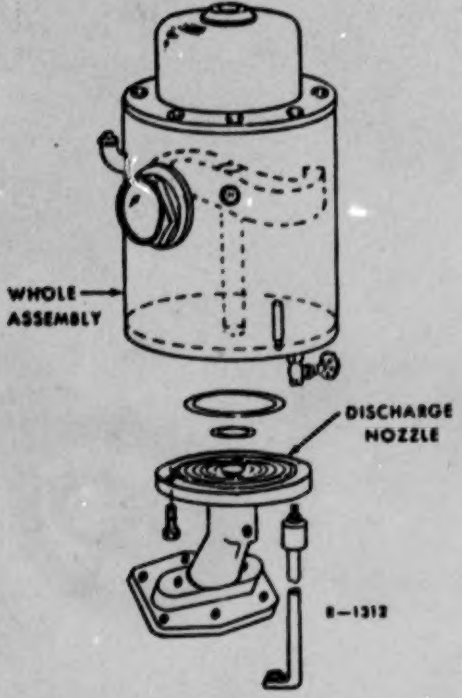
The effectiveness of a high-vacuum pump depends on the oil seal that is formed between the piston and the inside of the pump chamber, illustration below. A source of power is applied to the pump shaft, causing the circular movement of the piston. As the piston moves in its circular motion, a suction or low pressure is formed in the pump. The low pressure is developed with each turn of the shaft and piston. The intensity of the low pressure, formed in the pump, depends on the quality of the oil seal. Thus, the low pressure will cause the molecules of air to flow in the inlet of the pump. The movement of the air molecules in the pump is indicated by the arrows shown in the pump inlet, illustration below.



Cycle of Operations.

The low pressure in the pump pulls the molecules of air from the LOX tank being pumped. The air is drawn through the inlet (vacuum) hose into the cylinder when the piston is in the down stroke. On the up stroke of the piston, the air molecules removed from the LOX tank, are forced out the the outlet valve and discharged through the oil separator, page 77, to the atmosphere. Repetition of this operation for a period of time continues to improve the vacuum in the tank.

2927



Model KS-13 High Vacuum Pump Assembly Oil Separator.

Select the following statement(s) that is/are true.

_____1. The effectiveness of the vacuum pump depends on the teflon seal between the piston and outside chamber.

_____2. Air is pumped from the LOX tank, thru the pump and discharged to atmosphere.

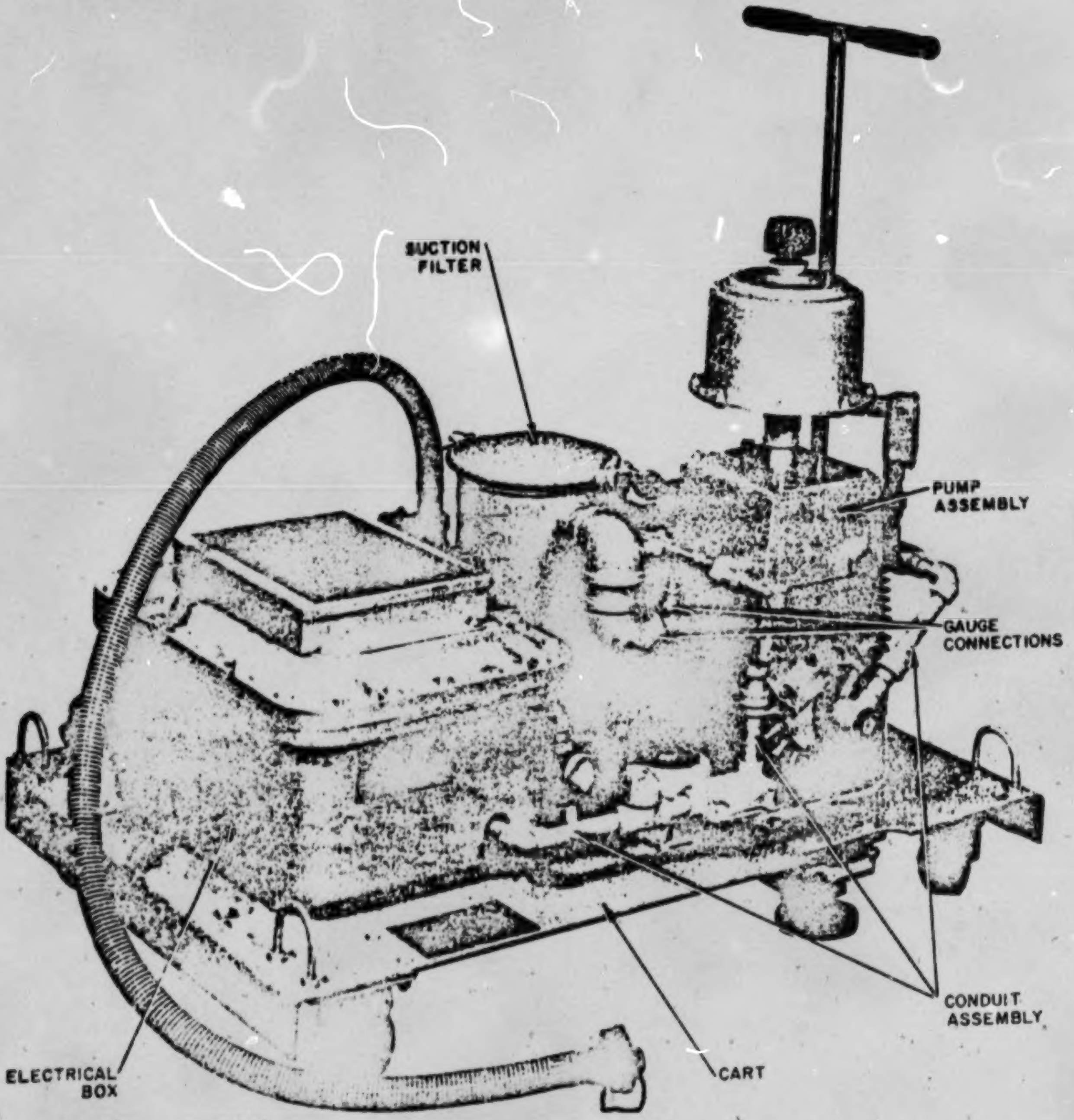
_____3. As the piston moves in its circular motion, a suction or low pressure is formed in the pump.

2928

Answers to Frame 52: ____1. __T__2. __T__3.

Frame 53

The model KTC-21 vacuum pump, below, is a three cylinder air-cooled, two-stage, mechanical pump. The pump is designed to evacuate the annular space of a cryotainer.


SUCTION FILTER
PUMP ASSEMBLY
GAUGE CONNECTIONS
CONDUIT ASSEMBLY
CART
ELECTRICAL BOX

Power Driven Rotary Vacuum Pump.

NO RESPONSE REQUIRED

Answers to Frame 53: NO RESPONSE REQUIRED

Frame 54

VACUUM PUMPING OF LIQUID STORAGE TANKS

When the vacuum of a tank, with liquid in the inner tank, is greater than the micron reading specified by the applicable TO, a pump-down is required. Prior to pump-down of the vacuum in the annular space of a LOX tank, be sure the inner tank is empty and warm. After the inner tank has been drained, a hot purge kit is used to warm the inner tank before pumping the vacuum. The lower the vacuum reading, the more effective the tank is for storing LOX.

When vacuum pumping has been completed, the vacuum valve on the tank is closed tightly before the pump is stopped. This valve is then rewired in the closed position. Removing the pump and then filling the tank with liquid oxygen is the way to determine if the vacuum in the insulated annular space is sufficient to store liquid oxygen. The procedures for vacuum pumping the insulated annular space of a LOX storage tank are listed in TO 37A12-1-101. These TO procedures and checklist must be followed during operation.

Note: Many more hours of pumping will be required to pump down the vacuum if the inner tank has liquid oxygen in it.

Select the following statement(s) that is/are true.

_____1. The tank must be warm and empty prior to pump down.

_____2. The higher the vacuum reading the more efficient the tank is for storing LOX.

_____3. After pump down is completed the vacuum valve is safety wired in the closed position.

_____4. Vacuum pump down may be accomplished quicker if LOX is in the tank during pump down.

2930

Answers to Frame 54: T 1. ____ 2. T 3. ____ 4.

Frame 55

VACUUM PUMP OIL

The oil used in the vacuum pump is MIL-L-83767, Tape II.

Tricresylphosphate is a special grade of oil used in oil-seated vacuum pumps. It has the two characteristics that are required for best operation at high vacuum.

1. A very low vapor pressure which does not rise materially at temperatures up to 122°F.

2. A degree of viscosity which does not become too great at temperatures of 60°F and which stays the same at temperatures of up to 122°F.

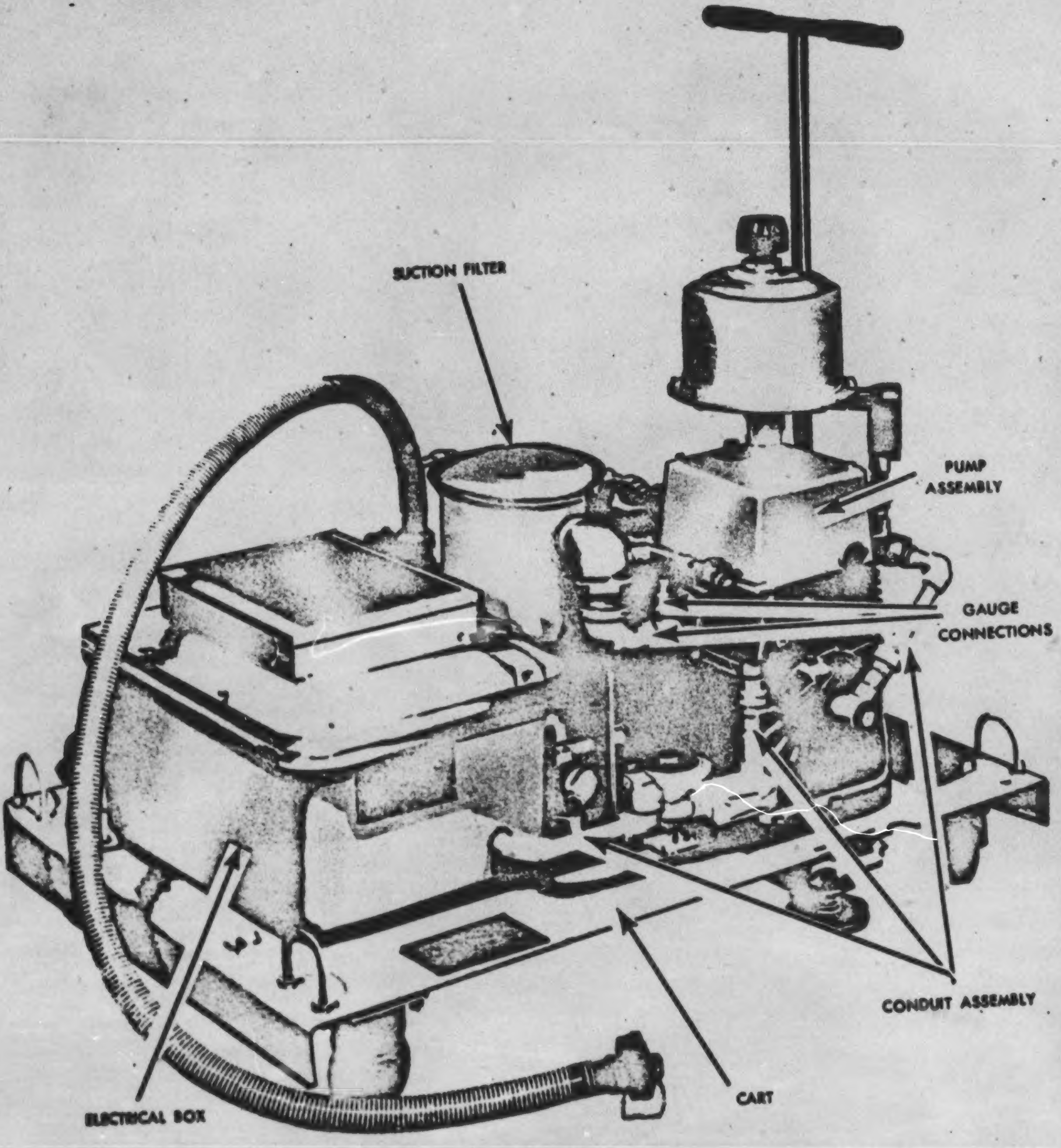
The low vapor pressure is of extreme importance for use in all vacuum pumps. Because of the high vacuums involved, any fraction with appreciable vapor pressure, even in minute quantities, remaining in the oil reduces the speed of evacuation. This oil must always be used to achieve the guaranteed performance of all oil-seated vacuum pumps.

Select the following statement(s) that is/are true.

____ 1. Tricresylphosphate is a special oil used in vacuum pumps.

____ 2. Oil is used to achieve the "seal" in all oil seated vacuum pumps.

2931


SUCTION FILTER
PUMP ASSEMBLY
GAUGE CONNECTIONS
CONDUIT ASSEMBLY
CART
ELECTRICAL BOX

Answers to Frame 55: T 1. T 2.

Frame 56

Tricresylphosphate is a toxic oil. While you are operating or servicing the vacuum pump, the lubricant may come in contact with your skin. If this happens, wash the affected area thoroughly with soap and water. Any time the pump is to be operated make sure it is in a well ventilated area. Avoid breathing the vapors from the pump exhaust.

The oil in the vacuum pump should be changed when it becomes dirty or contaminated. Anytime the oil becomes discolored it is an indication of contamination. This oil normally is clear. In case of an emergency, oil can be poured through a strainer and dry nitrogen blown through it to take out any trace of moisture.

Select the correct statement(s) that is/are true.

_____1. Tricresylphosphate is toxic and should not be allowed to come in contact with the skin.

_____2. The pump may be operated indoors in a closed area.

_____3. The oil must be changed after 200 hours of pump operation.

Answers to Frame 56: _T_ 1. ____ 2. ____ 3.

PERIODIC INSPECTION OF VACUUM PUMP

To keep the vacuum pump in a safe operational condition the following items should be inspected as indicated:

1. Lubricant: When applicable, drain a small amount of oil through the drain valve on the oil separator into a glass container. Let it set for 1 hour, then examine for solid particles, sludge, and water.

2. Check oil level daily for first week of operation and weekly thereafter. Oil level should be midway on the sight glass when operating at low inlet pressures.

3. Inspect suction filter each 250 hours.

4. Inspect oil mist eliminator each 250 hours.

5. Check cart casters (apply correct grease) each 100 hours.

6. Check all attaching hardware for security, damage, and wear each 250 hours.

NO RESPONSE REQUIRED

2934

Answers to Frame 57: NO RESPONSE REQUIRED

Frame 58

The air purging unit, type GSU-62/M, is intended primarily for use in purging liquid oxygen storage tanks, two illustrations shown on next page.

PURGE UNIT

The motor is a 5 - horse power, 3-phase, 60-cycle unit operating at 3600 rpm. The motor is designed to operate on 220 or 440 volts AC.

The blower is a rotary, positive displacement, 3-lobe rotor designed unit. It is capable of delivering oil-free air to the heater at 6 pounds per minute. The blower end plates have oil passages to allow free flow of lubricant between the bearings and seals without contaminating the air being delivered.

The heater assembly consists of six electrical heating elements mounted in an insulated cylindrical chamber. Its purpose is to heat the incoming air from the blower that is thermostatically controlled. The air at the outlet of the purge unit is 350°F.

The air intake opening of the blower is protected by a permanent type washable filter. The air filter can be disassembled and cleaned by washing it in water and a household detergent. Wipe the filter and blow it dry after cleaning.

From the list of statements below, match the component to its stated purpose/function.

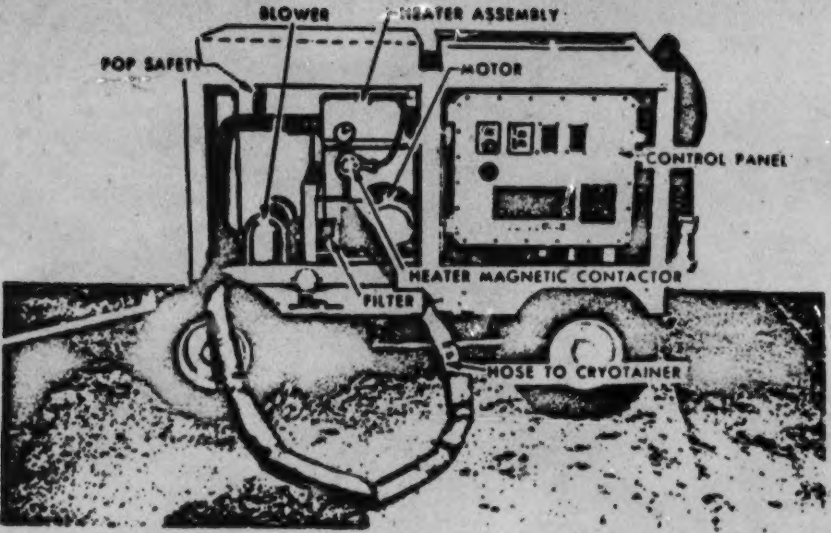
1. Used to heat the incoming air from the blower
2. Can be disassembled and cleaned by washing it in water and a detergent.
3. Capable of delivering oil-free air to the heater at 6 lbs per minute.
4. A 5 hp 3 ph. 60 cycle unit which operates at 3600 rpm.

a. motor

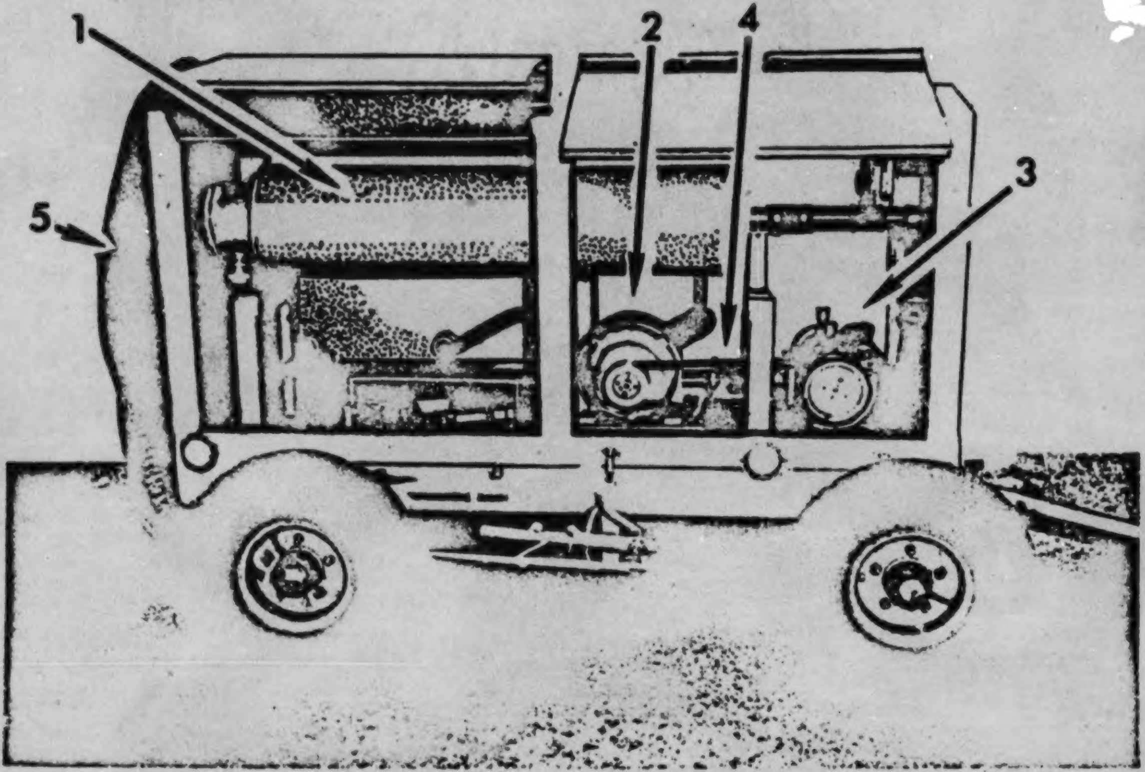
b. blower

c. heater assembly

d. air filter


BLOWER
HEATER ASSEMBLY
POP SAFETY
MOTOR
CONTROL PANEL
HEATER MAGNETIC CONTACTOR
FILTER
HOSE TO CRYOTAINER

Air Purging Unit, Type GSU-6/2/M - Left Side.


1
2
4
3
5
R-1314

1. Heater assembly.
2. Motor.
3. Blower.
4. Filter.
5. Electrical power cable.

Air Purge Unit, Type GSU-62/M - Right Side.

Answers to Frame 58: 1. c 2. d 3. b 4. a

Frame 59

HEATER MAGNETIC CONTACTOR

This control receives power from the heater circuit breaker and is controlled by a thermoswitch located in the heater outlet line. If the heater outlet temperature exceeds 350°F, the magnetic contactor will cycle automatically and interrupt power to the heater.

THERMOSWITCH

This switch is factor adjusted at 350°F. In the field, you can adjust the switch with a screwdriver. Rotate the adjustment clockwise to increase the temperature setting and counterclockwise to decrease it.

Caution: Do not attempt to change the temperature setting more than a few degrees at a time.

OVERHEAT THERMOSTAT

This is a protective device located inside the control panel, but its sensing element is in the heater chamber. The overheat thermostat is factory set at 400°F, but it can be readjusted by rotating the control knob. If this thermostat opens, the entire 110 volt control will be disconnected and the blower and heater will not operate.

Select the following statement(s) that is/are true.

_____1. In the field, the thermoswitch can be adjusted with a screwdriver.

_____2. If the heater outlet temperature exceeds 350°F, the magnetic contactor must be cycled manually.

_____3. If the overheat thermostat opens, the 110 volt control is disconnected.

Answers to Frame 59: _T_ 1. ____ 2. _T_ 3.

Frame 60

PRESSURE SWITCH

The pressure switch is activated by air through a connection on the blower outlet. Its purpose is to check for positive air pressure and must remain closed for blower operation.

TIME DELAY

The time delay relay is a thermal relay that provides the initial method of starting the motor. However, 45 seconds after the motor is started the relay will open and the pressure switch will maintain motor operation.

OPERATING CONTROLS

HOURMETER

The hourmeter is a time totalizer which indicates the number of hours the equipment has been in operation. It serves as a guide for determining when the unit is to be inspected.

NO RESPONSE REQUIRED

Answers to Frame 60: NO RESPONSE REQUIRED

Frame 61

THERMOMETER

There are two dial gages. One, which is located on the outlet line of the heater, indicates the outlet air temperature of the heater. The other is a clamp-on device, which indicates the temperature out of the system being purged.

48 VOLT POWER (GRID SYSTEM)

This is a switch with a red indicating light (1) to show when power is available to the unit for operation, page 89. The indicating light is mounted above the phase reversal switch.

MOTOR CIRCUIT BREAKER

This circuit breaker, page 89 (3), controls energizing power to the motor and permits the motor to be started by pressing the motor START-STOP switch. In the event of an overload the circuit breaker will trip to the OFF position, stopping the motor.

HEATER CIRCUIT BREAKER

This circuit breaker (4) controls the electrical power to the six heater elements. If the heater overloads for any reason the circuit breaker will trip, interrupting the power to the heater elements.

PHASE REVERSAL SWITCH

The purpose of this switch (1) is to prevent damage to the blower by driving it in the wrong direction. Always wait for the blower to come to a dead stop before attempting to reverse its direction.

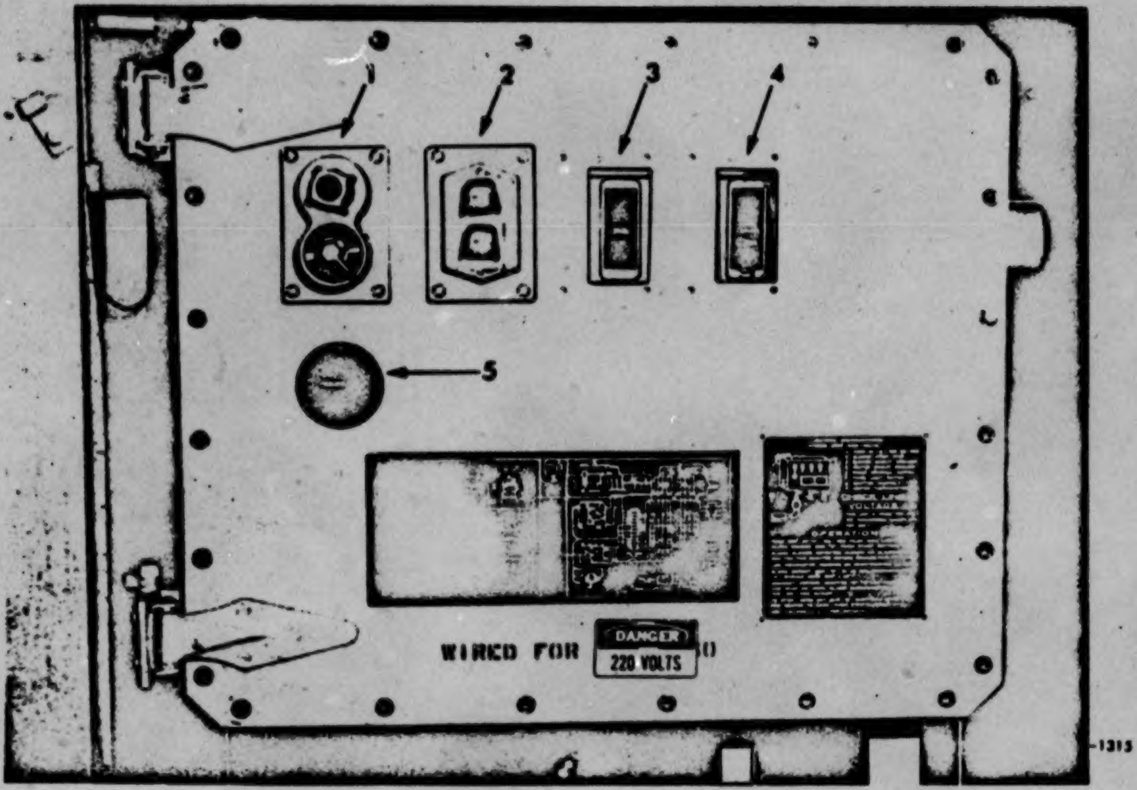
Select the following statement(s) that is/are true.

1. The thermometer on the outlet line of the heater indicates outlet air temperature.

2. The unit which permits the motor to be started by pressing the Start/Stop switch is the heater circuit breaker.

2939

Answers to Frame 61: _T_ 1. ____ 2.


1
2
3
4
5
WIRED FOR
DANGER
220 VOLTS
-1315

1. Power on 48 volt grid system.
2. Start/Stop Blower/Motor.
3. Circuit breaker blower.
4. Circuit breaker heater.
5. Hourmeter.

Air Purging Unit Control Panel.

323

2940

Frame 62

From the list of functions/operations below, associate 8 of 10 to the components of the air purging unit and control panel. Match, by number, the function/operation to the component.

_____ 1. Indicates the outlet air temperature out of the system being purged.

_____ 2. A red indicating light to show that power is available for operation.

_____ 3. Controls energizing power to the motor and permits the motor to be started by pressing the START/STOP switch.

_____ 4. Prevents damage to the blower by its being driven in the wrong direction.

_____ 5. Indicates the number of hours the equipment has been in operation.

_____ 6. Provides the initial of starting and opens 45 seconds after motor is started.

_____ 7. Checks for positive air pressure and maintains motor operation.

_____ 8. When open, disconnects the entire 110 volt control and the heater will not operate.

_____ 9. May be adjusted in the field with screwdriver.

_____10. Cycles automatically at 350°F and interrupts power to the heater.

a. Heater magnetic contactor

b. Thermoswitch

c. Overheat thermostat

d. Pressure switch

e. Time delay

f. Hourmeter

g. Phase reversing switch

h. Motor circuit breaker

i. 48 volt power (grid system)

j. Thermometer.

324

Answers to Frame 62: 1. j 2. i 3. h 4. g 5. f
6. e 7. d 8. c 9. b
10. a

The following are questions for you to use in summarizing pages 50 thru 90. Try to answer the questions on your own but if you are uable to do so, turn to the top of the next page and you will find the frame number where each question may be located.

QUESTIONS

1. How are LOX storage tanks cleaned and degassed?
2. What approved cleaning solvent is used for cleaning parts of the LOX storage tank plumbing?
3. What is the required pressure when transferring liquid oxygen?
4. What is used to pressurize a LOX storage tank when checking for leaks?
5. What conditions affect the performance of the vacuum pump?
6. When should the lubricant in the vacuum pump be changed?
7. What type of lubricant is used in vacuum pumps?
8. The effectiveness of a high vacuum pump depends upon?
9. The controlled outlet temperature of the air leaving the purge unit heater is?
10. What is the function of the phase reversal switch on the purge unit?
11. What type of sealing compound is used on connections on LOX storage tanks?
12. What is the indication that the transfer hose has developed a leak?

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Answers to questions on page 91.

1. Frame 32
2. Frame 32
3. Frame 36
4. Frame 35
5. Frame 50
6. Frame 55
7. Frame 54
8. Frame 51
9. Frames 58 and 59
10. Frame 61
11. Frames 34 and 35
12. Frame 45

2943

WORKBOOK
3ABR42331-WB-404

Technical Training

Aircraft Environmental Systems Mechanic

INSPECTION AND MAINTENANCE OF CRYOTAINERS

6 March 1979

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE

DO NOT USE ON THE JOB

ATC FORM 214 (JAN 76) OBSOLETES ATC FORMS 214, MAY 69, 522, NOV 63 AND 523, MAY 71. STANDARD COVERSHEET

2944

Environmental/Pneudraulic Branch
Chanute AFB, Illinois 61868

Service Test
3ABR42331-WB-404

INSPECTION AND MAINTENANCE OF CRYOTAINERS

OBJECTIVES

1. Using a cryotainer, tools, inspection, workcard, inspect cryotainer and components, locating three discrepancies and record on AFTO Forms 349. One instructor assist per form is permissible.

2. Using a TMU-27M LOX cart, GSU-62M purging unit, and workbook, purge cryotainer. Four instructor assists are permissible.

3. Using a KC-15 vacuum pump, vacuum microngage and 50-gallon cryotainer, evacuate cryotainer. Three instructor assists are permissible.

4. Using assigned cryotainer and proper tools, remove and reinstall three of the eleven selected components. One instructor assist is permissible.

EQUIPMENT

	Basis of Issue
3ABR42331-WB-404	1/student
Cryotainer	1/4 students
TO 37A12-1-101	1/4 students
TO 36F2-3-1	1/4 students
Vacuum pump	1/4 students
Purge unit	1/4 students
Microngage	1/4 students
Tools	As required (kit)
TO 00-25-06-2-2	1/student
AFTO Form 26	As required
AFTO Form 349	As required

INSTRUCTIONS

This workbook contains information to guide you in performing the inspection and maintenance of cryotainers. Use the technical orders while you work and to complete the AFTO Forms 349. The technical orders provide specific instructions to follow and the

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necessary procedures which may prevent injury to you or others and damage to valuable equipment. As you complete each phase, have your instructor check your work and initial in the space provided. Work carefully and observe all safety precautions. DO NOT HURRY!

PART I - INSPECTION

Using the AFTO Form 26, Inspection Workcard, inspect the assigned LOX cart. Locate and document three discrepancies. Using the TO 00-25-06-2-2, complete the three discrepancies on AFTO Forms 349 with one instructor assist permitted per form.

PART II - VACUUM CHECK

A microngage and thermocouple is used to check for the amount of vacuum present in the annular space of a cryotainer.

1. Read TO 37C11-3-1, Section II, para 2-1 and 2-2 and study Figure 1-2.

2. Perform a vacuum check on the MA-1, TMU-27M cryotainer assigned by the instructor and determine if it is good or bad.

Instructor's Initials__________

PART III - VACUUM PROCEDURES

Vacuum the annular space of the LOX cart with KTC-21 vacuum pump. Before using the vacuum pump, refer to Figure 2 in TO 37A12-2-101 and become familiar with the various components of the unit. Follow the step-by-step procedures listed below for vacuuming the LOX cart. DO NOT DEVIATE FROM THESE STEPS. If there is something that does not work or is broken or damaged, tell your instructor IMMEDIATELY.

1. Close the vacuum valve tightly. Have your instructor check it.

Instructor's Initials__________

2. Remove the bolts, nuts, and flat washers (Figure 3, Items 1, 2, 3) that secure the coupling cap (Item 4) to the coupling plate (Item 7) on the vacuum line.

3. Remove the coupling cap (Item 4) and seal (Item 6) from the coupling body (Item 7). Discard the old seal but save the blank plate (Item 4) for reinstallation after pump down.

4. Lightly coat a new seal with vacuum grease H-90. Next, install the seal into the coupling body and install the vacuum pump hose fitting (Item 8) on the coupling plate (Item 7). Reinstall the two bolts, flat washers, and nuts. Tighten the nuts until there is metal to metal contact between the hose fitting and coupling plate.

2946

5. Lightly coat the hose coupling of the vacuum pump hose fitting (Item 8) with vacuum grease. Install the servicing hose from the vacuum pump over the male end of the vacuum pump hose fitting (Item 8). Secure the hose to the fitting with a hose clamp. Coat the joint between the hose and fitting with vacuum grease.

6. Remove the safety wire from the vacuum valve but DO NOT OPEN the valve.

Instructor's Initials__________

7. Start the vacuum pump to evacuate the air from the vacuum hose. With the vacuum pump running, SLOWLY open the vacuum pump not more than ONE-QUARTER TURN. This is necessary to prevent a sudden inrush of air into the vacuum filter within the tank annulus, which could cause packing of insulation against the filter. Wait a few minutes and SLOWLY open the vacuum valve to the fully open position.

Instructor's Initials__________

8. The tank can be considered to have adequate vacuum when the micron reading is less than 100 microns with the tank at purging temperature. Pumping should be continued, however, to the lowest possible micron reading, preferably below 100 microns. If the tank cannot be pumped down to 300 microns measured on the thermocouple gage after 3 to 3½ hours of continuous pumping, there is a leak in the vacuum system. For leak detection and repair beyond base capability, request depot assistance in accordance with TO 00-25-107.

9. With the vacuum pump running, close and safety wire the vacuum valve to prevent accidental opening of the valve.

Instructor's Initials__________

10. Stop the vacuum pump and disconnect it from the vacuum pump hose fitting (Item 8). Remove the two bolts, four flat washers, and two nuts that secure the vacuum pump hose fitting to the coupling plate (Item 7), remove the hose fitting end seal. Discard the seal.

11. Coat the new seal with vacuum grease and install the seal in the coupling body (Item 6). Position the coupling cap (Item 4) on the coupling plate (Item 7) and coupling body. Secure with two bolts, four flat washers, and two nuts.

Instructor's Initials__________

The next part of this workbook will direct you in performing maintenance on selected components. This is to prepare you for maintaining the equipment you will be working with. The technical order containing the information you need to repair the units listed beside each item. Work carefully and do not hurry.

PART IV - PURGING PROCEDURES

Cryotainers are not purged on a periodic (time) basis, but rather when the percentages of contaminants reaches an undesirable level as determined by (1) laboratory tests, (2) odor of particulate testing. In this event, the storage tank must be drained and purged. Purging is the process of forcing heated air or nitrogen through the drained tank causing residual liquid oxygen (LO_2) and any contaminants which entered the tank to be converted to a gaseous state and dispelled from the tank.

NOTE: The contaminants primarily consist of acetylene (C_2H_2), carbon dioxide (CO_2), nitrous oxide (N_2O), and other forms of hydrocarbons which tend to settle to the bottom of the tank as solids at the cold liquid oxygen temperature.

PURGING FREQUENCY

(1) No periodic schedule for purging of tanks or carts.

(2) Requirements for draining and purging are established in Technical Order 42B6-1-1.

(3) Evidence of contamination of a storage tank will require all servicing carts used to transport liquid oxygen from the source to be purged along with the tank to assure complete disposal of the contaminated LO_2.

Instructor's Initials__________

SAFETY: Before you begin to work with liquid oxygen, you must first be aware of some of the hazards in working with oxygen. Observe all safety precautions outlined in technical orders, including the wearing of protective devices to prevent bodily contact with liquid oxygen. Make certain the ground areas onto which the LO_2 will be discharged are free of all hydrocarbons (oil, grease, lumber or wood, macadam, grass, etc). These are not compatible with liquid oxygen and spontaneous fire or explosion may result.

STEP 1

1. Remove the filter from the fill and drain line. On units which have separate fill and drain filters, remove both filters.

2. Before starting the purging procedures, make sure that the LOX cart has no liquid or pressure in it.

3. Position the air purging unit type GSU-62/M within 10 feet of the tank vent line. (If purging unit is not available, heated nitrogen gas may be used.) Connect the puring unit to a source of 220/440-volt, 3-phase, 60-hertz AC power. Connect the servicing hose of the purging unit to the tank vent line. Vent line adapters are available with the unit. Attach the temperature gage furnished with the purging unit to the male fitting of the fill and drain line.

4. Before operating the purging unit, read TO 36G2-3-1, Section 2, page 3-9.

Instructor's Initials__________

5. Start the purging unit and let it run for 20 minutes with the heater switch "OFF."

6. After running the unit for 20 minutes with the heater switch "OFF," turn the heater switch "ON" and let the unit run until the drain line fitting is approximately 104°C or 220°F.

7. After the unit has been stopped, open the pressure buildup valve and close the fill and drain valve.

8. Disconnect all tubing at the liquid level gage, pressure gage, hose pressure relief valve, and rupture disc. Remove the thermometer from the hose quick disconnect fitting and replace with a dust cap.

Instructor's Initials__________

9. Start the purging unit. Crack the fill and drain valve enough to get a moderate flow at the hose relief valve and rupture disc opening. Continue the purging until all circuits have been purged for at least one hour or until all solvent vapors or fumes have been removed. Reassemble all instruments and safety device tubing.

10. Disconnect the purging unit servicing hose and remove the temperature gage from the tank. Store them in the purging unit.

11. Reconnect the pressure buildup line to the vent line. When making the connection, use anti-seize tape on the pipe threads before assembling the pipes. Start the application of the tape at the third thread to prevent contamination of the system.

12. Close the fill and drain valve and the vent valve and leave them closed until the tank is filled with liquid oxygen. This will prevent moist air or other contaminants from entering the tank.

Instructor's Initials_________

13. Clean the filters and flush the hose with trichloroethylene and then dry them with the purging unit.

14. Install the dry filters in the fill and drain lines.

15. Install the transfer hose.

Instructor's Initials_________

PART V - MAINTENANCE

The instructor will select and give to you three out of the 11 components listed below. These components with TO number, page, and paragraph number listed along side of it, refer to that reference and follow the step-by-step procedures you will find there. Those items without the TO reference listed follow the step-by-step procedures listed in this workbook.

NOTE: Before performing any maintenance on the LOX cart, make sure that the cart is empty and there is no pressure in the lines.

1) Pressure rupture disc/MA-1/TO 37A12-1-101, page 4-5, para 4-18, fig 4-7.

2) Quantity gage/MA-1TO 37A12-1-101, pages 4-8 & 9, para 4-35.

3) Pressure gage/MA-1/TO 37A12-1-101, page 4-8, para 4-34.

4) Transfer hose/MA-1

a. Using a spanner wrench, loosen the end of the hose that connects the hose to the cart.

b. After the hose is loose, use your hands to remove the hose completely.

c. To reinstall the hose, reverse the steps.

4a) Transfer hose/TMU-27M

a. Using a ford wrench, unscrew the hose from the cart.

b. After the hose has been removed, clean both ends thoroughly.

c. After both ends have been thoroughly cleaned, apply new anti-seize tape to the male part of the cart.

d. After the anti-seize tape has been installed, screw the hose back in to the cart and use a ford wrench to tighten.

5) Transfer hose filler valve/MA-1/TMU-27M/TO 37A12-1-101, fig 4-11, page 4-13.

a. Using a 7/8" and a 9/16" wrench, unscrew the filler valve from the transfer hose.

b. Remove the old anti-seize tape from the valve and clean the hose and the valve thoroughly.

c. After the hose and valve have been cleaned thoroughly, apply new anti-seize tape to the valve.

d. To install the new part, reverse step (a).

6) Transfer hose shutoff valve/MA-1/TMU-27M

a. Using a ford wrench, turn the base of the valve counterclockwise and then remove the valve.

b. After the valve has been removed, clean the male portion of the manifold. Then clean the female portion of the valve, making sure both parts are free from dirt, dust, oil, etc.

c. After both parts have been thoroughly cleaned, apply anti-seize tape to the male portion of the manifold.

d. Now you are ready to install the part onto the cart. Place the valve squarely on the male part of the manifold and screw the valve clockwise (making sure the valve is not crossthreaded). Now tighten the valve using the ford wrench.

7) Tubing/MA-1/TMU-27M

a. Using the appropriate size wrench, depending upon the size of the tubing and "B" nuts, turn the "B" nuts counterclockwise and then remove.

b. To install the tubing, reverse step (a) (making sure that the "B" nuts are not crossthreaded).

8) Cart filler valve/TMU-27M

a. Using a ford wrench, turn the base of the valve counterclockwise and then remove the valve.

v. After the valve has been removed, clean the male portion of the manifold. Then clean the female portion of the valve, making sure both parts are free from dirt, oil, dust, etc.

c. After both parts are thoroughly cleaned, apply anti-seize tape to the male portion of the manifold.

d. Now you are ready to reinstall the part back onto the cart. Place the valve squarely on the male part of the manifold and screw the valve clockwise (making sure the valve is not crossthreaded). Now tighten the valve using the ford wrench.

9) Vent valve/MA-1

a. Use the samp steps as for the shutoff valve.

9a) Vent valve/TMU-27M

a. Using a 12" crescent wrench, turn the base of the valve counterclockwise and then remove the valve.

b. After the valve has been removed, clean the male portion of the valve and the female portion of the manifold, making sure both parts are free of dirt, oil, dust, etc.

c. After both parts are thoroughly cleaned, apply anti-seize tape to the male part of the valve.

d. Now you are ready to reinstall the part back onto the cart. Place the valve squarely in the female part of the manifold and screw the valve clockwise (making sure the valve is not crossthreaded). Now tighten the valve using the crescent wrench.

10) Buildup valve/TMU-27M/MA-1

a. Use the same steps as for the shutoff valve.

11) Pressure relief valve/MA-1

a. Using a 5/8" open end wrench, remove the tubing attached to the rear end of the valve, turning the "B" nut counterclockwise.

b. Now remove the cotter pin connecting the pull handle to the valve and remove the handle.

c. Using a common screwdriver and 3/8" wrench, remove the two screws and bracket holding the relief valve to the side of the cart.

d. For installation, reverse the steps for removal.

Instructor's Initials__________

PART VI - OPERATIONAL AND LEAK CHECK

Upon completion of Parts I-V, it will be necessary to perform a leakage and operational check on the cryotainer.

2952

PROCEDURE

Obtain a servicing checklist from your instructor and follow all safety and general instructions. Pay strict attention to all procedures, especially safety. If you have any questions, ask your instructor. You will be working with liquid nitrogen; therefore, it is imperative that you be sure of what you are doing before you do it.

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2953

PROGRAMMED TEXT
3ABR42331-PT-405

Technical Training

Aircraft Environmental Systems Mechanic

LIFE RAFT INFLATION EQUIPMENT

22 September 1977

3350 TECHNICAL TRAINING WING
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

2954

FOREWORD

This programmed text was prepared for use in the 3ABR42331, Aircraft Environmental Systems Mechanic Course. It was validated using students enrolled in the 3ABR42331 Course. At least 90% of the students achieved the objectives as stated. The average time required to complete this text is 55 minutes.

OBJECTIVE

Relate three (3) of five (5) components of life raft inflation equipment to their operation.

INSTRUCTIONS

This programmed text consists of two sections. The material contained in section "A" is on the construction of life raft inflation cylinders.

Section "B" information is on the operation of the life raft inflation cylinders.

The information in this text is presented in small steps called "frames." After reading the information in each fame, you are asked to select answers or respond, in some manner, to show that you understand the information in that frame. As you progress through the lesson you will be instructed to either write your answer in the booklet or on a separate response sheet. The answers to each frame can be found on top of the following page. If you select the correct answers, continue to the next frame. If you are wrong or in doubt, read the material again and correct yourself before proceeding. Work carefully and DO NOT HURRY!!!

Supersedes 3ABR42231-PT-316, 19 February 1971.
OPR: 3370 TTG
DISTRIBUTION: X
3370 TTGTC - 400; TTVSR - 1

2955

Frame 1

Our career field is not responsible for the maintenance of life rafts, but we do have the responsibility of servicing, inspecting, overhauling, and recharging all life raft inflation equipment. For this reason, it is necessary for you to know the means by which these life rafts are inflated.

NO RESPONSE REQUIRED

2956

Frame 2

High pressure carbon dioxide (CO_2) cylinders are used for the inflation of all life rafts. The cylinders are built to carry a maximum charge of 2100 psi. Because of the high pressure to which they are subjected, all life raft cylinders except those having an outside diameter of less than two inches and a length of less than two feet, must undergo a hydrostatic test once every five (5) years. This test is used to find out whether or not corrosion, metal fatigue, rough handling, or other causes may have weakened the cylinders to a point where they are no longer safe for further use.

Check the following statements that are true.

_____1. CO_2 cylinders are used for the inflation of life rafts.

_____2. Life raft inflation cylinders are built to carry a maximum pressure of 2100 psi.

In the following questions, select the answer which is most correct.

3. Life raft cylinders with a diameter of 1 1/2" would require a hydrostatic test how often?

   a. 1 year.

   b. 3 years.

   c. 5 years.

   d. Never.

4. Hydrostatic test determines if the cylinder is

   a. broken.

   b. repairable.

   c. safe for use.

   d. operating properly.

340

Answers to Frame 2: __✓__1. __✓__2. 3. d 4. c

Frame 3

All life raft cylinders are of two basic types, and they are used with either the one-man or the multiplace (two or more men) life rafts. (Throughout the remainder of this text the term one-man life raft cylinder or multiplace life raft cylinder will be used.) The size difference in the cylinders and the difference in valve assemblies are due mainly to the size of the life raft to which they are attached. All of the multiplace life raft cylinders are wound with wire to give them added strength and to make them shatter resistant when they are struck by gunfire. The valve assemblies are made for rapid flow and they always have a safety rupture disc. This disc will break and permit the whole charge to escape if the pressure in the life raft cylinder should rise to a dangerous limit.

Check the following statements that are true.

_____1. The size of the life raft inflation cylinders varies with the size of the life rafts to be inflated.

_____2. Cylinder valve assemblies always include a safety rupture disc.

_____3. All of the multiplace cylinders are wire wound.

_____4. The term multiplace means the cylinder inflates a life raft that holds more than one man.

In the following questions, select the answer which is most correct.

5. All multiplace life raft cylinders are wound with wire to give them added

   a. strength.

   b. pressure.

   c. resistance.

   d. durability.

6. The valve assemblies of multiplace life raft cylinders are made for

   a. slow flow.

   b. rapid flow.

   c. emergency stoppage.

   d. none of the above.

Answers to Frame 3: ✓ 1. ✓ 2. ✓ 3. ✓ 4. 5. a 6. b

Frame 4

All multiplace life raft cylinders have to be serviced so that they are able to be used in the temperature range of -65°F to +160°F by adding a charge of dry nitrogen (N_2) to the cylinder. The addition of N_2 to the cylinder provides additional pressure which helps to force out the CO_2 at a much higher rate when the temperature is low, than would the pressure of CO_2 alone. This is because the pressure of N_2 does not go down as much as CO_2 when the temperature goes down. A fast rate of discharge of the life raft cylinders at any temperature is very important. The life raft cylinder valve assembly provides a way of maintaining high pressure CO_2 in the cylinder and is designed to permit an unrestricted flow of gas to the life raft when it is actuated. Should the mechanic forget to add N_2 to a multiplace cylinder, it could cause under inflation of the life raft. The one man cylinders do not require an N_2 charge.

Check the following statements that are true.

_____1. The valve assembly permits a restricted flow of gas to the raft when actuated.

_____2. Adding N_2 to the CO_2 cylinder causes a lower pressure to allow the CO_2 to be discharged more slowly.

_____3. N_2 pressure does not drop as much as CO_2 pressure when the temperature decreases.

In the following questions, select the answer which is most correct.

4. Multplace life raft cylinders may be used safely between the temperature ranges of

   a. -50 to +150 F.
   b. -65 to +160 F.
   c. -80 to +170 F.
   d. -95 to +180 F.

5. The component that provides a way of maintaining high pressure CO_2 in the cylinder is the

   a. wire wound cylinder.
   b. nitrogen charge.
   c. low temperature.
   d. valve assembly.

2959

Answers to Frame 4: ____1. ____2. __✓__3. 4. b 5. d

Frame 5

There are two types of one-man life raft cylinders that are approved for use. They are shown below. Both assemblies use the same valve head, but type FLU 2/P uses a heavy forged steel cylinder while type FLU 2-A/P uses a light weight aluminum welded cylinder. As you can see in figure 1, the light weight cylinder is slightly longer than the forged cylinder but they both contain the same amount of CO_2 by weight. These cylinders do not require a hydrostatic test.

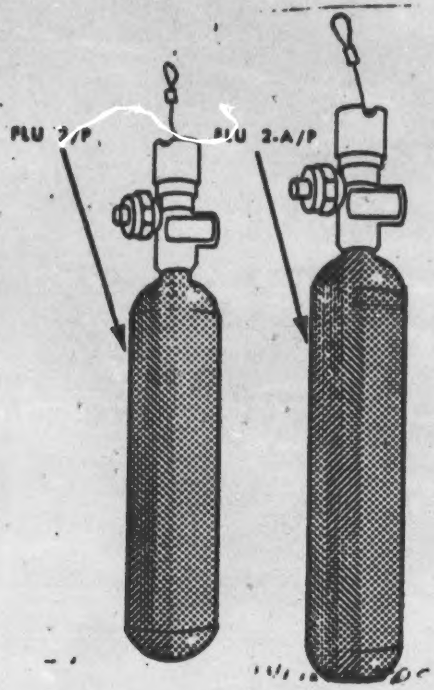


Figure 1. One-Man Cylinders.

Check the following statements that are true.

____1. The FLU 2A-P cylinder is slightly longer than the FLU 2/P cylinder.

____2. The FLU 2-A/P and FLU 2/P cylinders are less than two inches in diameter and less than two feet in length.

In the following question, select the answer which is most correct.

3. The basic difference between the two one-man cylinders is the

   a. valve head.
   b. rate of discharge.
   c. rupture disc plate.
   d. material that each is made from.

2960

Answers to Frame 5: ✓ 1. ✓ 2. 3. d

Frame 6

Refer to figure 2 while we discuss the operation of the valve that is used on the one-man life raft cylinders. A round ball (not shown) on the inner end of the cable assembly (A) is engaged in a slot in the rotating cam (O). The ball is engaged in the slot by raising a small locking spring in the slot (M), then sliding the locking sleeve (N) down to expose the cam, and then positioning the cable and ball assembly. When the cable is pulled, the cam rotates and pushes down on the check (I) which is normally held against its seat by the spring (J) and CO_2 pressure within the cylinder. The CO_2 now floods out the charge/discharge port into the life raft. If the pressure in the cylinder should become dangerously high, it will break the rupture disc (C) and the CO_2 will pass out through the holes in the insert (D) and out through the vent holes (F) in the valve body to the atmosphere. The diffuser plug (K) is installed at all times except when the assembly is being recharged or is actually attached to the life raft. The purpose of the diffuser plug is to prevent a pinwheel action of the cylinder resulting from the jet effect of the escaping gas if the cylinder is discharged.

Check the following statements that are true. (Refer to figure 2 if necessary.)

_____1. When the cable (A) is pulled, the cam (O) pushes the check valve (I) to release the CO_2 from the cylinder (H).

_____2. The diffuser plug (K) is removed during recharging of the assembly.

_____3. If the rupture disc (C) is missing, the assembly can still be recharged.

In the following questions, select the answer which is most correct.

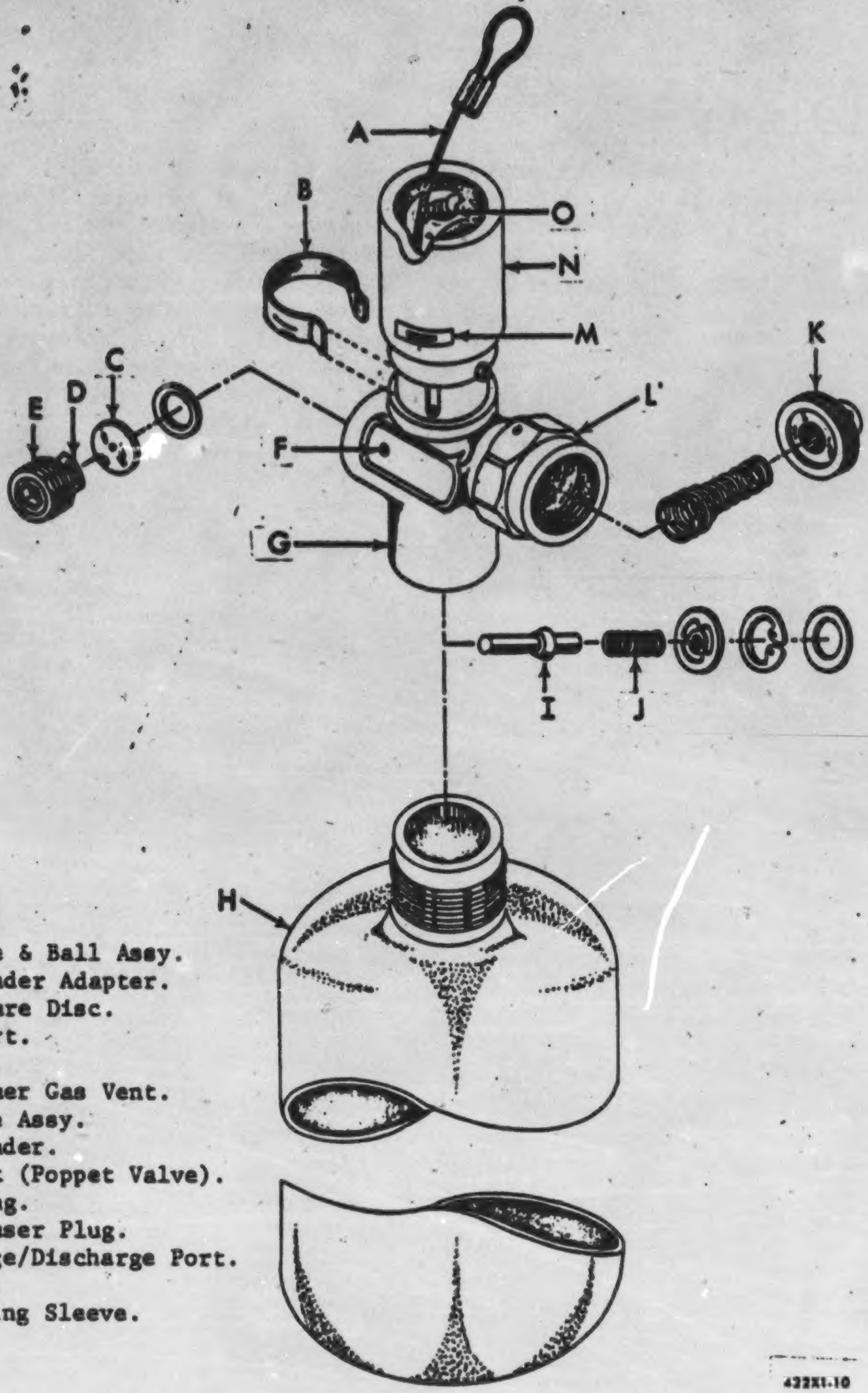
4. Using figure two as a guide, the purpose of item C is to

   a. release the pressure.
   b. recharge the cylinder.
   c. close the valve.
   d. open the valve.

5. Using figure two as a guide, the purpose of item K is to prevent

   a. rupturing.
   b. discharging.
   c. pin wheeling.
   d. overcharging.

344


A
B
O
N
M
C
D
E
F
L'
K
G
I
J
H
422X1-10

A - Cable & Ball Assy.
B - Cylinder Adapter.
C - Rupture Disc.
D - Insert.
E - Plug.
F - Ruptuer Gas Vent.
G - Valve Assy.
H - Cylinder.
I - Check (Poppet Valve).
J - Spring.
K - Diffuser Plug.
L - Charge/Discharge Port.
M - Slot.
N - Locking Sleeve.
O - Cam.

Figure 2. One-Man Assembly.

Answers to Frame 6: __✓__1. __✓__2. _____3. 4. a 5. c

Frame 7

Refer to figure 3 while we discuss the operation of the valve that is used on the multiplace life raft cylinders. When the pull cable (M) is pulled to discharge the cylinder, it rotates a sheave (D). A hole in the sheave fits over a pin that is located on a cam that is below the sheave. The rotation of the cam depresses a lever arm which contacts the end of the poppet valve (I) and pushes it down. With the poppet valve unseated, the gas rushes out through the charge/discharge port (C) and inflates the life raft. When the cylinder is charged, the spring (J) and gas pressure hold the poppet valve (I) closed. Notice that this cylinder has a syphon tube (K) to insure that the liquid CO_2 is discharged as well as the gas.

Check the following statements that are true. (Refer to figure 3 if necessary.)

_____1. A syphon tube (K) is used to insure that gas escapes from the cylinder before the liquid escapes.

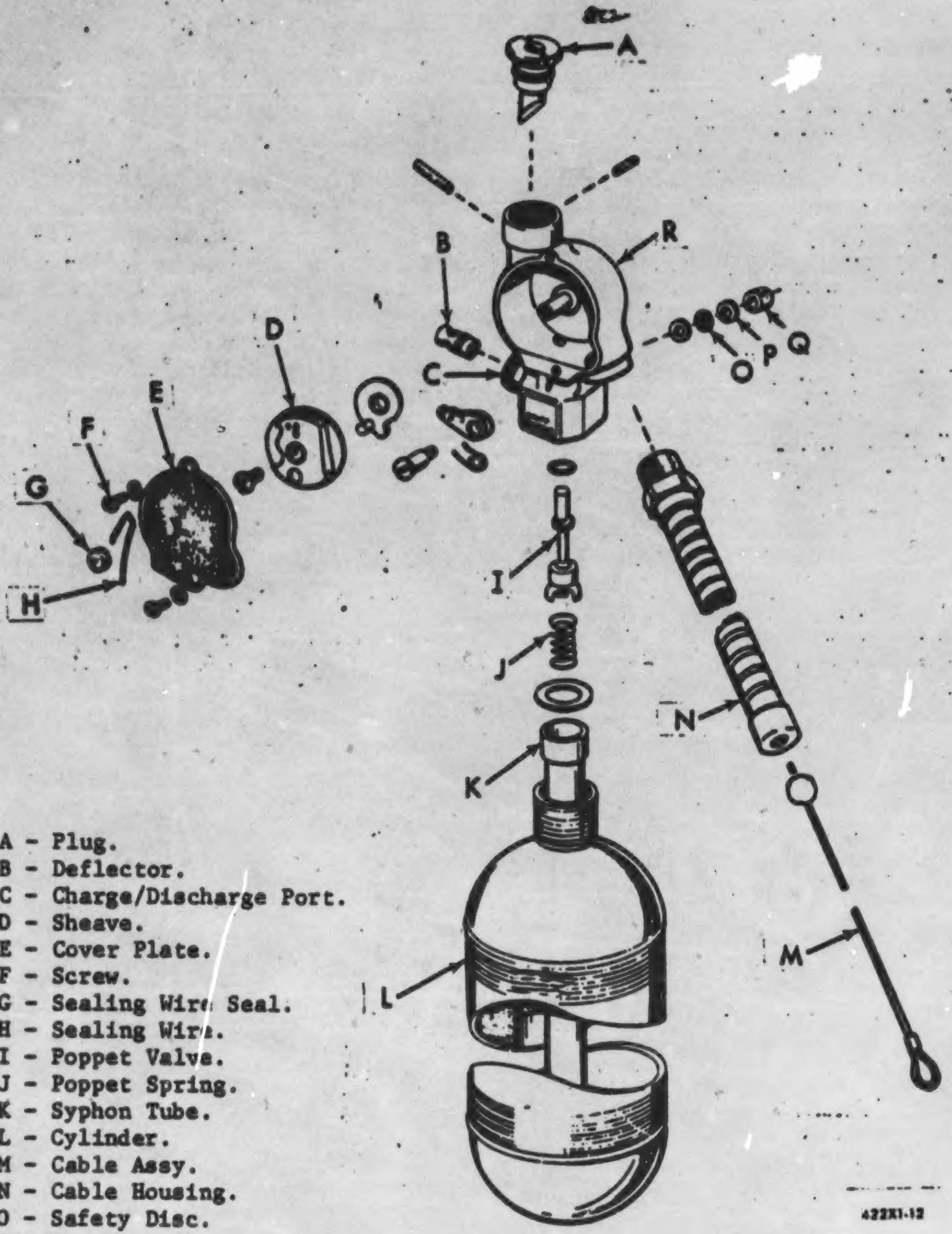
_____2. The charge/discharge port (C) has a safety disc installed.

For the following questions, fill in the blanks with the most correct answer.

3. When rotated, the __________ will cause the ______ _______ to open, and discharge the cylinder.

4. When the cylinder is charged, the ___________ and __________ pressure hold the __________ ___________ closed.

2963


A
R
B
D
E
F
G
H
C
O
P
Q
I
J
K
N
L
M
422X1-12

A - Plug.
B - Deflector.
C - Charge/Discharge Port.
D - Sheave.
E - Cover Plate.
F - Screw.
G - Sealing Wire Seal.
H - Sealing Wire.
I - Poppet Valve.
J - Poppet Spring.
K - Syphon Tube.
L - Cylinder.
M - Cable Assy.
N - Cable Housing.
O - Safety Disc.
P - Insert.
Q - Plug.
R - Body.

Figure 3. Multiplace Assembly.

2964

Answers to Frame 7: ____1. ____2. 3. cam, poppet valve

4. spring, gas, poppet valve

Frame 8

The release cable can be rigged in either the DOWN PULL position as shown in figure 4, or in the UP PULL position by reversing the positions of the cable housing (N) and the plug assembly (A) as shown in figure 3. The ball on the end of the cable must be engaged in the proper recess on the sheave marked DOWN PULL or UP PULL. As long as the control cable has not been pulled to discharge the cylinder, a green dot on the sheave shows through the window in the sheave cover plate, as indicated in figure 4. When the cylinder is charged and rigged for use, a lead seal is placed on the safety wire which passes through two holes in the sheave cover plate and is twisted around a cover hold-down screw (figure 4). Once the cable has been pulled and the sheave rotated to discharge the cylinder, it cannot be reset without breaking the seal and removing the cover plate. Items O, P, and Q in figure 3 are the rupture disc, insert, and plug which allows escape of the gas if the cylinder pressure should become dangerously high.

Check the following statements that are true. (Refer to figures 3 and 4 if necessary.)

____1. If the control cable has not been pulled, the green dot normally indicates a charged cylinder.

____2. The sheave cannot be reset unless the safety wire, seal, and cover plate are removed.

2965

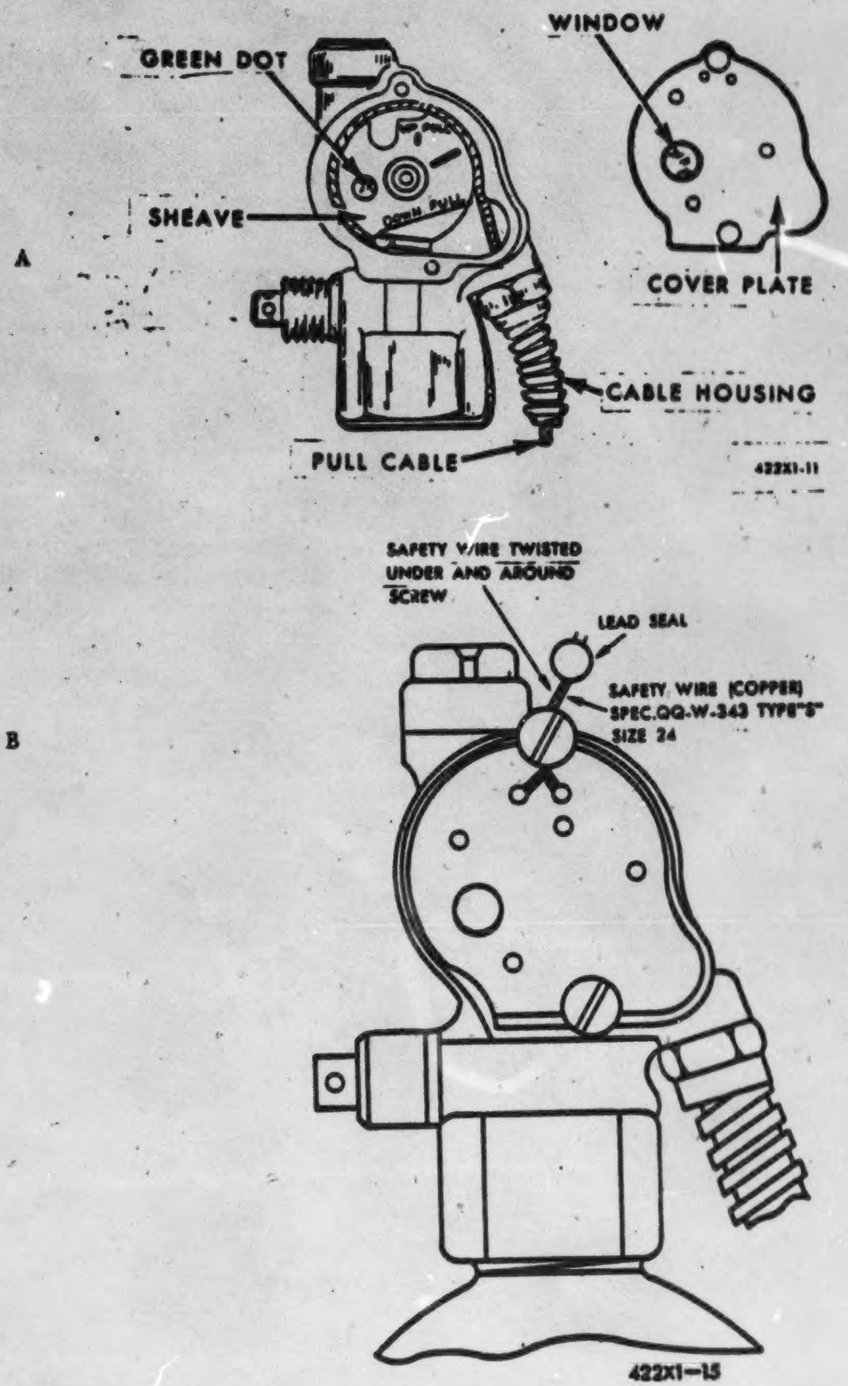

WINDOW
GREEN DOT
SHEAVE
A
COVER PLATE
CABLE HOUSING
PULL CABLE
422X1-11
SAFETY WIRE TWISTED UNDER AND AROUND SCREW
LEAD SEAL
SAFETY WIRE (COPPER) SPEC.QQ-W-343 TYPE"S" SIZE 24
B
422X1-15

Figure 4. Multiplace Control Head.

Answers to Frame 8: ✓ 1. ✓ 2.

2966

PROGRAMMED TEXT

3ABR42331-PT-405A

Technical Training

Aircraft Environmental Systems Mechanic

RECHARGING EQUIPMENT FOR AND MAINTENANCE OF LIFE RAFT CYLINDERS

28 November 1978

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

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Do Not Use on the Job.

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2967

FOREWORD

This programmed text was prepared for use in the 3ABR42331 instructional system. The material contained herein has been validated using 30 42010 students enrolled in the 3ABR42331 course. The average student required 54 minutes to complete the text.

OBJECTIVES

After completing the programmed text, you will be able to:

Relate four (4) of five (5) life raft inflation equipment components to their purpose.

INSTRUCTIONS

This programmed text presents material in small steps called frames. After each frame you will find questions. Read the information given and respond by entering the correct response on your response sheet. The answers to each frame are at the top of the next page. Anytime you respond incorrectly, reread the frame to get the information straight in your mind. Some frames do not require a response. When you have finished reading a frame that does not require a response, go directly to the next frame.

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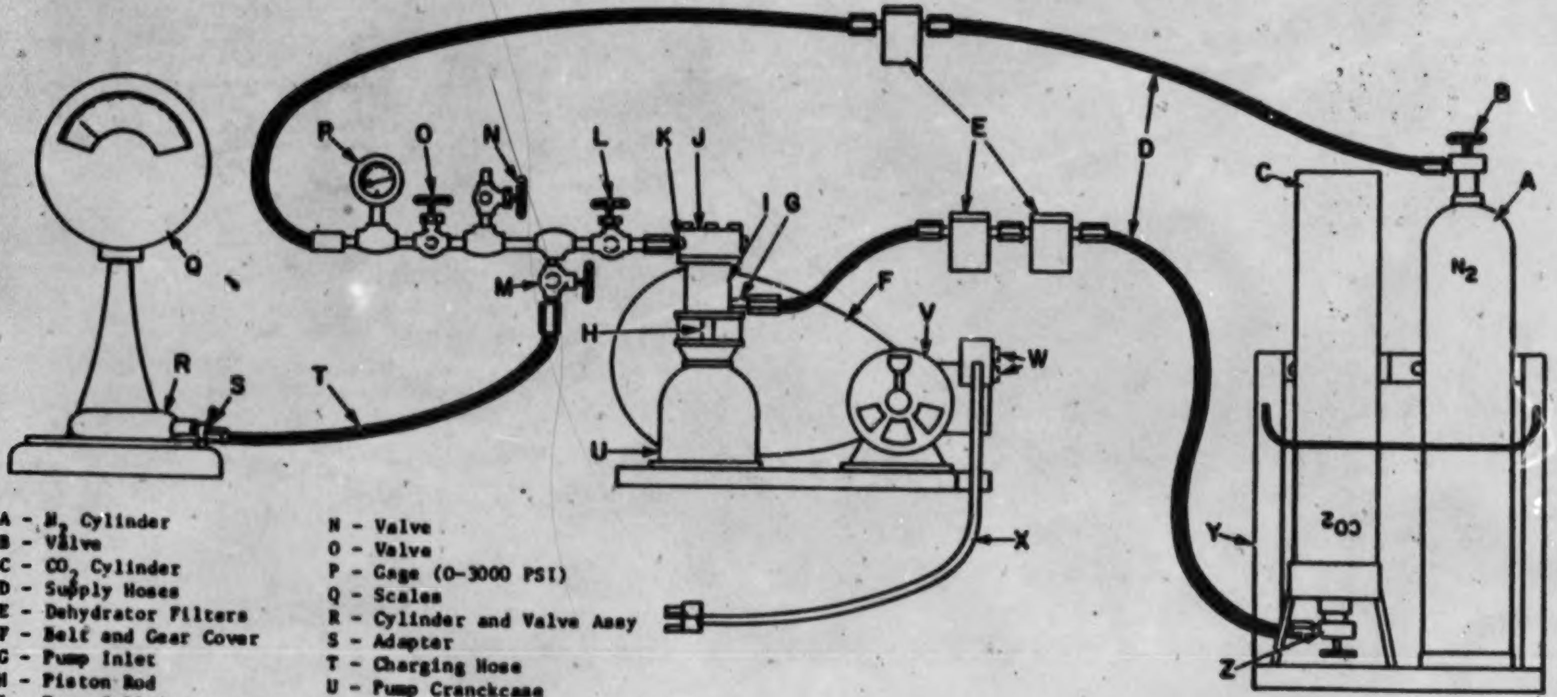
Frame 1

Figure 1 shows a typical equipment setup for charging one-man and multiplace life raft inflation cylinders. It consists of a motor driven pump, a scale, one CO_2 cylinder, one N_2 cylinder (both cylinders are placed on the same stand), dehydrator filters, a gage, shut-off valves, assorted metal hoses and adaptors. This is just a basic setup. Other variations may be used, but all will have much the same equipment as shown in figure 1.

NO RESPONSE REQUIRED



A - N_2 Cylinder
B - Valve
C - CO_2 Cylinder
D - Supply Hoses
E - Dehydrator Filters
F - Belt and Gear Cover
G - Pump Inlet
H - Piston Rod
I - Pump Cylinder
J - Cylinder Head
K - Pump Outlet
L - Valve
M - Valve

N - Valve
O - Valve
P - Gage (0-3000 PSI)
Q - Scales
R - Cylinder and Valve Assy
S - Adapter
T - Charging Hose
U - Pump Cranckcase
V - Motor
W - Start/Stop Buttons
X - Power Cord
Y - Frame
Z - Valve

Figure 1.

Answers to Frame 1: NO RESPONSE REQUIRED

Frame 2

The pump drive motor may be a three phase, 220 VAC unit or a single phase, 115 VAC unit of sufficient horsepower to drive the charging pump. Power is transferred from the motor to the pump by a drive belt. The pump is a ram type unit that will pump only liquid, it will not pump gas of any kind. Since the pump will pump only liquid, it is important to keep the CO_2 as cool as possible in order that more liquid will be available for cylinder charging. The pumping equipment is protected from damage by a rupture disc or by a spring-loaded relief valve that will relieve the system if the pressure becomes excessively high. The maximum pressure for a specific pumping unit may be found in the applicable technical order.

Complete the following statements by writing in the words from the frame above.

a. One requirement for the pump drive motor, regardless of its power requirement, is that it have sufficient ________________ to drive the ______________.

b. CO_2, in the storage cylinder, must be kept as ____________ as possible because the pump will not transfer __________ of any kind.

c. If charging pressure should become excessively high, the pumping equipment is protected from damage by a ______________ disc or a spring-loaded ________________ valve.

2971

Answers to Frame 2: a. horsepower, pump b. cool, gas
c. rupture, relief

Frame 3

Four shutoff valves are located on the charging control panel to control the flow of liquid and gas to the cylinder being charged. Valve O controls the flow of N_2 to the charging hose from the supply cylinder; valve L controls the flow of CO_2 from the charging pump; valve M is the shutoff valve to the charging hose for both liquid and gas. Valve N is a dump valve which is used to dump pressure from the supply hoses after the cylinder has been charged and valves L and O have been closed.

Mark the following statements with a T for True or an F for False.

_____1. The purpose of the shutoff valves is to control the flow of liquid and gas that are used to charge the inflation cylinder.

_____2. The flow of liquid or gas into the charging hose is controlled by valve M.

_____3. After the cylinder has been charged, pressure is dumped from the supply hoses by opening valve Z.

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2972

Answers to Frame 3: ____T____ 1. ____T____ 2. ____F____ 3.

Frame 4

Dehydrator filters E are installed in both the liquid and gas supply hoses D from the supply cylinders A and C to remove any moisture from these agents before they are put into the cylinder R. One filter E is installed in the N_2 supply hose and two are installed in the CO_2 supply hose, in series. The hoses, fittings, adaptors and shutoff valves are of the brass, high pressure type. The adaptors S are used to connect the charging hose to the cylinder R that is to be charged. A gage P is installed in the N_2 supply hose, on the control panel, as a means of determining the quantity of N_2 supply. The scale Q used to weigh the cylinder assembly and the N_2 and CO_2 charges must be graduated to read in hundredths of a pound.

Complete the following statements by writing in the words from the frame above.

a. Dehydrator filters are installed in the ____________ and __________ supply hoses to remove ________________ from these agents before they are put into the cylinder.

b. ______________ filters are installed in ____________ in the CO_2 supply hose and one is installed in the ______________ supply hose.

c. A _____________ is installed in the N_2 supply hose as a means of determining the quantity of the ______________ supply.

d. The scale used to weigh the cylinder and the ____________ and ______________ charges must be graduated to read in _____________ of a pound.

e. The hoses, fittings, adaptors and ____________________________ valves are of the brass, ___________ pressure type.

2973

Answers to Frame 4: a. N_2, CO_2, moisture b. Two, series, N_2

c. gage, N_2 d. N_2, CO_2, hundredths

e. shutoff, high

Frame 5

The source of supply for the CO_2 is a standard ICC (Interstate Commerce Commission) shipping and storage cylinder C (N_2 comes in a similar cylinder). The CO_2 cylinder, when fully charged, contains 50 pounds of CO_2. At 70°F, 12 pounds of this weight will be gas and 38 pounds will be liquid. The proportion of liquid will be greater at lower temperatures. Before installing a new cylinder of CO_2, determine if the cylinder has a syphon tube. If the cylinder has a syphon tube, it must be installed with the valve up so that the liquid may be drawn off before the gas. If the cylinder does not have a syphon tube, it must be installed with the valve down so that the liquid may be drawn first. The N_2 cylinder A is always installed with the valve up. Both cylinders must be firmly secured to keep them from falling over.

Complete the following statements by writing in the words from the frame above.

a. The shipping and storage CO_2 cylinder contains ____________ pounds of ________________ when fully charged.

b. At 70°F, a fully charged CO_2 shipping and storage cylinder will contain ______________ pounds of liquid and ____________ pounds of gas.

c. At 0°F, the weight of the liquid CO_2 in the cylinder will be ________________ (greater, less) than the weight of the liquid CO_2 at 70°F.

d. If the CO_2 cylinder has a syphon ______________, it must be installed with the valve ___________________.

e. The N_2 cylinder is always installed with the valve ___________.

Answers to Frame 5: a. 50, CO_2 b. 38, 12 c. greater
d. tube, up e. up

Frame 6

Before the charging hose T is attached to the cylinder, it must be purged of air to insure that no moisture is injected into the cylinder R along with the liquid or gas. To purge the charging hose, the N_2 valve O, the charging hose shutoff valve M and the N_2 cylinder, shutoff valve B must be opened to allow N_2 to flow through the charging hose. After the charging hose has been purged, it is immediately attached to the cylinder R to be charged. This prevents moisture laden air from reentering the charging hose to be injected into the cylinder. The cylinder and valve assembly, with the charging hose attached, is placed on the scale Q to obtain its empty weight reading. This is used as a reference weight to determine what the full weight indication on the scale should be when the specified pounds of N_2 and CO_2 are added during the charging operation. The full weight will be the empty weight plus the specified pounds of N_2 and CO_2 to be added.

Mark the following statement with a T for True or an F for False.

_____1. The charging hose must be filled with air before it is attached to the cylinder.

_____2. Purging the charging hose insures that no oxygen is injected into the cylinder.

_____3. After the charging hose has been purged, it is immediately attached to the pump.

_____4. The cylinder and valve assembly, with the charging hose attached, is placed on the scale to obtain a reference weight.

2975

Answers to Frame 6: _F_ 1. _F_ 2. _F_ 3. _T_ 4.

Frame 7

The charging equipment does not require a great amount of maintenance. Before using it, give it a visual inspection for obvious defects and cleanliness. Scheduled inspections, lubrication intervals and types of lubricants are given in the applicable technical order. The TO also gives instructions for repair and overhaul of this equipment. The more common troubles encountered with this equipment are also listed in the TO along with the remedies for them.

Complete the following statements by writing in the words from the frame above.

a. Before operating the charging equipment, give it a ____________ inspection for _______________ defects and ___________________.

b. Requirements for inspections, lubrication intervals and types of _________________________ required are given in the applicable _______________ ____________.

c. Most common ___________ and the ___________ for them are given in the TO along with instructions for _____________ and overhaul.

360

2976

Answers to Frame 7: a. visual, obvious, cleanliness
b. lubricants, TO c. troubles, remedies, repair

Frame 8

All cylinders returned for charging are subjected to a very thorough inspection to insure that they are free from defects and that they are protected from exposure to corrosion. The specific inspection requirements are given in the applicable technical order. Any cylinder that fails to meet these inspection requirements is tagged as reparable and set aside for further inspection and repair. Only those cylinders having no defects may be recharged.

Mark the following statements with a T for True or an F for False.

_____a. Before a cylinder is recharged, it is inspected to insure that it is free from defects and protected from exposure to corrosion.

_____b. Cylinders that fail to meet inspection requirements are tagged as serviceable and set aside for further use.

_____c. Cylinders that have no defects may be recharged.

2977

Answers to Frame 8: __T__a. __F__b. __T__c.

Frame 9

General overhaul of multiplace cylinders includes disassembly, cleaning, inspection, repair and reassembly as directed by the applicable technical order. The cylinders are hydrostatically tested every five (5) years (quinquennial test) at 5/3 the cylinder working pressure (Example: 5/3 x 2100 psi = 3500 psi). Cylinders having an outside diameter of less than two inches and a length of less than two feet are exempt from the quinquennial test.

Complete the following statements by writing in the words from the frame above.

a. A hydrostatic or quinquennial test is not required on the one-man cylinder because it is less than ________________ inches in diameter and ____________ than _____________ feet in length.

b. The hydrostatic or quinquennial test is performed on cylinders every ____________ years at ____________ the cylinder working pressure.

c. General overhaul of the multiplace cylinder includes disassembly, cleaning, ________________, _________________ and reassembly.

d. A cylinder having a working pressure of 2400 psi would be hydrostatically tested using _______________ psi.

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Answers to Frame 9: a. two, less, two b. 5, 5/3
c. inspection, repair d. 4000

Frame 10

The hydrostatic or quinquennial test indicates the permanent volumetric expansion of the cylinder. The test is conducted by placing the cylinder in a water jacket and measuring the amount of water displaced when the cylinder is pressurized. Water is forced into the cylinder under pressure to meet the requirements indicated in the formula given in frame 9 in order to stretch the cylinder. Internal water pressure must be maintained for not less than 30 seconds. After the water pressure has been released from the cylinder, the remaining permanent volumetric expansion of the cylinder must not exceed 10% of the total volumetric expansion which occurred during pressurization. The date of the latest hydrostatic test is stamped on the cylinder below the previous date mark. Cylinders that fail the hydrostatic test are made unserviceable by damaging the threads and tagging the cylinder CONDEMNED.

Mark the following statements with a T for True or an F for False.

_____a. Permanent volumetric expansion is shown by the hydrostatic test.

_____b. The permanent volumetric expansion remaining after pressure has been released from the cylinder must not exceed 15 percent of the total volumetric expansion which occurred during pressurization.

_____c. Cylinders that fail the hydrostatic test are made unserviceable by damaging the threads and tagging the cylinder as serviceable.

_____d. The date of the hydrostatic test is painted on the cylinder below the previous date.

Answers to Frame 10: _T_ a. _F_ b. _F_ c. _F_ d.

Frame 11

Before the charging operation is begun, each cylinder must be weighed individually and the weight checked against the weight stenciled on the cylinder. These two weights should be the same. If they are not the same, the cylinder must be restenciled with the weight down on the scale. Different, information is required on the one-man than on the multiplace cylinders, so check the applicable TO before you cut the stencil and start spraying paint. For your information, this information is also included in frame 19 of this text.

Mark the following statements with a T for True or an F for False.

_____a. After the cylinder has been inspected, it must be weighed and the date checked against the date stenciled on the cylinder.

_____b. If the two weights are not the same, the cylinder must be restenciled with the weight shown on the scale.

_____c. The information to be stenciled on the one-man cylinder is different from the information to be stenciled on the multiplace cylinder.

Answers to Frame 11: __F__a. __T__b. __T__c.

Frame 12

Remember from a previous text, that at cold temperatures, CO_2 gas changes to a liquid. Consequently, at temperatures below $0^\circ F$, the CO_2 pressure in the cylinder will drop considerably--possibly to the point where the CO_2 will not discharge fast enough to effectively inflate the life raft. For this reason, multiplace cylinders are given a charge of dry nitrogen, N_2, to serve as a propellant for the CO_2 charge. Nitrogen pressure will remain high at temperatures as low as $-65^\circ F$. The amount of nitrogen to be added to the cylinder, by weight, may be found in the applicable technical order. This information is also included as a part of frame 13 of this text.

Complete the following statements by writing in the words from the frame above.

a. At low temperatures, CO_2 tends to ____________________, therefore, at $0^\circ F$, the liquid content of the cylinder would be ____________________ (greater, less) than at a temperature of $80^\circ F$.

b. At temperatures below $0^\circ F$, CO_2 pressure in the cylinder will _______________ considerably and may not effectively ______________ the life raft.

c. For cold weather operation, _____________ N_2 is added to the cylinder to act as a _________________ for the CO_2 charge.

d. The pressure of _______________ will remain high at temperatures as low as ___________ $^\circ F$.

2981

Answers to Frame 12: a. liquefy, greater b. drop, inflate
c. dry, propellant d. N_2, -65

Frame 13

When charging the multiplace cylinder, N_2 is first injected into the cylinder as directed in the applicable TO. After the specified amount of N_2, by weight, has been added to the cylinder, the CO_2, is added. The N_2 and CO_2 charges have specified weights which must be within the weight limits shown in the technical order. The amount of N_2 added to the cylinder depends on the capacity of the cylinder in cubic inches. Charging procedures for the one-man cylinder are the same as for the multiplace cylinder, except that the N_2 charge is left out. When charging any inflation cylinder, protective clothing consisting of gloves and a face mask or goggles must be worn.

Mark the following statements with a T for True or an F for False.

_____a. The amount of N_2 added to a cylinder depends on the capacity of the cylinder in cubic inches.

_____b. Charging procedures for the one man cylinder are the same as for the multiplace cylinder, except that the N_2 charge is left out of the one-man cylinder.

_____c. When charging any cylinder, a face mask or goggles and rubber apron must be worn.

366

Answers to Frame 13: T a.   T b.   F c.

Frame 14

The CO_2 used to charge all life raft cylinders must conform to Grade B, Type I or II of Specification BB-C-101. All CO_2 used to charge life raft cylinders is passed through two dehydrator filters connected into the supply hose in series before it is injected into the cylinder. The dehydrator filter cartridges, to insure continued drying action, must be replaced whenever 250 pounds of CO_2 have passed through them.

Complete the following statements by writing in the words from the frame above.

a. All CO_2 used to charge ________ ________ cylinders is passed through ____________ dehydrator filters connected into the supply hose in ______________ before it is injected into the cylinder.

b. The CO_2 used to inflate life raft cylinders is passed through _________________ dehydrator filters to insure that there is no _________ in the CO_2 when it is injected into the cylinder.

c. To insure the continued effectiveness of the ______________ filters, they must be replaced after ____________ pounds of ____________ have been passed through them.

2983

Answers to Frame 14: a. life raft, two, series b. two, moisture
c. dehydrator, 250, CO_2

Frame 15

As mentioned in a previous frame, recharging procedures for the multiplace and one-man cylinders are generally the same. There are some small differences, one of which was the omission of the N_2 charge from the one-man cylinder. Another difference is based upon the construction of the valve assembly. On the one-man cylinder, you will find it necessary to open the valve before you can charge the cylinder with CO_2. The multiplace assembly may be charged without rotating the sheave to open the valve. This is due to the construction of the valve assembly, which acts as a check valve. Just hook it up and its ready to receive the charge.

Complete the following statements by writing in the words from the frame above.

a. When charging the one-man cylinder the ___________ charge is _________ ____________.

b. To charge the multiplace cylinder, it is not necessary to open the _______________ because the internal construction of the unit acts as a _______________ valve.

c. The valve assembly on the ________ - _________ cylinder must be _______________ before it will accept a charge.

368

Answers to Frame 15: a. N_2, left out b. valve, check
c. one-man, open

Frame 16

It may require some practice on your part before you will be able to charge a cylinder and get it within the tolerances specified in the technical order. The tendency is to overcharge the cylinder. If the cylinder is overcharged, the excess charge must be removed. Check the technical order for "bleed off" procedures and don't forget to install the diffuser plug before you "bleed off" the excess. By installing the diffuser plug, you are protecting yourself from injury from the jet of high pressure CO_2 which will be released from the cylinder when you open the valve. Don't forget your protective equipment, this is a must throughout the charging procedure. In case you've forgotten what the protective equipment is, put on gloves and face mask or goggles during all charging operations. Remember that CO_2 absorbs a great amount of heat during the evaporation process and can cause severe frostbite to the unwary or careless individual.

Complete the following statements by writing in the words from the frame above.

a. The diffuser plug is installed in the cylinder charge/discharge port to prevent __________ from the jet of escaping high pressure ________________.

b. Caution must be exercised during the bleed off operation because CO_2 absorbs a great amount of __________ and can cause severe ________________.

c. If a cylinder is overcharged, the excess must be ____________ off in accordance with procedures outlined in the applicable ___________ ________________.

d. Protective equipment consisting of ____________ and a _________ ___________ or ______________ must be worn during all charging operations.

2985

Answers to Frame 16: a. injury, CO_2 b. heat, frostbite
c. bled, technical order d. gloves, face mask, goggles

Frame 17

After charging the cylinder, the charging hose T must be disconnected to permit the attachment of another cylinder to the charging equipment. First, insure that the N_2 and CO_2 control valves are closed. Open valve N to bleed off or DUMP pressure from the supply hoses. The charging hose may be cleared at this time by opening valve M and releasing the pressure through valve N. First, insure that the valve on the inflation cylinders is in the closed position. O.K., now slowly loosen the adaptors between the charging hose and the cylinder, just in case there's still some pressure and liquid left in the charging hose. After all pressure has been released from the lines, and the cylinder disconnected, close all valves to keep moisture from entering the system.

Complete the following statements by writing in the words from the frame above.

a. After the cylinder has been charged and disconnected from the charging hose, the charging hose must be plugged and all valves must be

______________ to prevent _____________ from entering the system.

b. The charging unit supply hoses are depressurized by ____________

valve _______________.

c. When disconnecting the charging hose from the cylinder, the

adaptor should be loosened _______________ as a safety precaution.

d. Before opening valve N, insure that the ______________ valve

and the ______________ valve have been _____________.

370

2986

Answers to Frame 17: a. closed, moisture b. opening, N
c. slowly d. N_2, CO_2, closed

Frame 18

After the fully charged cylinder has been removed from the charging unit, two leakage checks must be performed. The first is a water tank check performed under reflected light. The cylinder is submerged in a tank of water for 30 minutes and observed for bubbles rising to the surface of the water. If there are indications of leakage during this test, the point of leakage must be located and corrected. The cylinder must then be recharged and another leakage test performed. If no leakage is evident, the cylinder is stored for a period of 24 hours, as specified in the applicable TO. At the end of the 24 hour storage period the cylinder is reweighed. The allowable weight loss for the one-man cylinder is 1/100th of the weight of the CO_2 charge immediately after charging. For the multiplace cylinder the allowable weight loss is 1/100th of a pound in 24 hours. When both of these checks have been satisfied, the cylinder is considered to be serviceable.

Mark the following statements with a T for True or an F for False.

_____a. Leakage from a recharged cylinder during the water tank test is indicated by dye rising to the surface of the water.

_____b. During the water tank leakage check, the cylinder is submerged in the dye tank for a period of 30 minutes.

_____c. It requires 24 hours to perform a valid weight loss check of the cylinder contents.

_____d. If, during the water tank leakage check, bubbles are seen rising to the surface of the water, the point of leakage must be located and the leak repaired and the cylinder recharged.

2987

Answers to Frame 18: F a. F b. T c. T d.

Frame 19

After the cylinder has been charged, leak tested and reweighed, it must be stenciled with specific information to identify the cylinder, its contents and the date that it was charged. This information is stenciled on the cylinder using black stencil ink or black lacquer. One-fourth inch letters are used for the one-man cylinder and one-half inch letters for the multiplace cylinder. Stencils will be cut to include the information listed below. Look this information over closely so that you will know what is to be put on the cylinder. Always check this in the TO.

ONE-MAN CYL

CYL AND VALVE ASSY

TYPE FLU 2/P

WT EMPTY 1.55 LBS

WT CO_2 0.50 LBS

TOTAL WT 2.05 LBS

DATE RECHARGED 1 SEP 70

2100 PSI 147.63KG/CM_2

MULTIPLACE CYLINDER

CYLINDER AND VALVE ASSY

PART NO. ____________

WT EMPTY ________ LBS (includes complete valve assy and atchs)

WT CO_2 ________ LBS (enter nominal charge)

WT N_2 and CO_2 ________ LBS (enter actual weight)

WT TOTAL ________ LBS

DATE CHARGED ____________

FLEXIBLE SYPHON TUBE

U.S. PROPERTY

Complete the following statements by writing in the words from the frame above.

a. The multiplace cylinder is stenciled using ________ inch letters and ________ ____________ ink or black ____________.

b. The one-man cylinder is stenciled using ________ inch letters and ____________ ink or black ____________.

c. The information stenciled on the cylinder should identify the cylinder, its ____________ and the ____________ it was charged.

Answers to Frame 19: a. 1/2, black, stencil, lacquer
b. 1/4, black, lacquer c. weight, date

2988

WORKBOOK
3ABR42331-WB-405

Technical Training

Aircraft Environmental Systems Repairman

INSPECTION, OPERATION, AND RECHARGING LIFE RAFT CYLINDERS

14 July 1978

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

2989

Environmental Pneudraulic Branch 3ABR42331-WB-405
Chanute AFB, Illinois

INSPECTION, OVERHAUL, AND RECHARGING LIFE RAFT CYLINDERS

OBJECTIVES

1. Using the inflation cylinder recharging equipment, scales, and tools, prepare and service a life raft cylinder to within 1/100 lbs of its specified weight.

2. Using an assigned life raft cylinder and tools, inspect the valve head assembly and cylinder. One (1) instructor assist is permissible.

EQUIPMENT

	Basis of Issue
Recharging Unit, Carbon Dioxide	1/student
Scale, Dial and Beam Indicating	1/student
One-man Life Raft Inflation Cylinder	1/student
Multiplace Life Raft Inflation Cylinder	1/student
Handtools	1/student

PROCEDURE

Now that you have completed the programmed texts covering the operation, maintenance, and recharging of life raft cylinders, you should be familiar enough with the equipment to do the required tasks. Refer to figure 1 for an illustrated breakdown of the cylinder assembly. Do the steps given for each section of this workbook.

Section 1. INSPECTION AND OVERHAUL OF ONE-MAN LIFE RAFT INFLATION CYLINDER ASSEMBLY

1. Using the one-man life raft cylinder provided (type FLU-2A/P or FLU-2/P), visually inspect the cylinder for the following conditions:

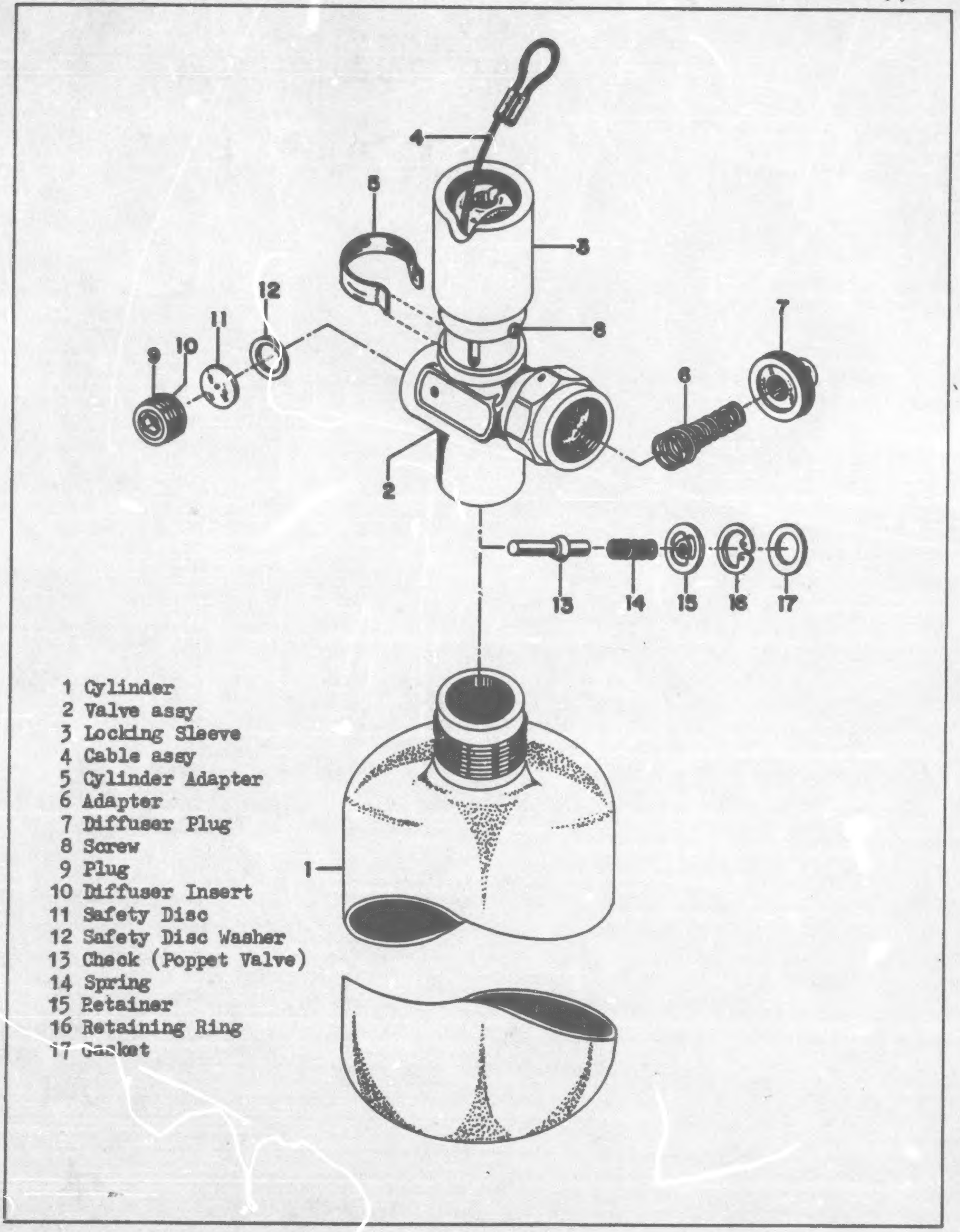
   a. Rust on the cylinder (none allowed).

   b. Excessive dents in the cylinder (none allowed).

   c. Condition of the paint.

Supersedes 2ABR42231-WB-404, 1 June 1971.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370TCHTG/TTGU-P - 600; TTVSA - 1

2990



1 Cylinder
2 Valve assy
3 Locking Sleeve
4 Cable assy
5 Cylinder Adapter
6 Adapter
7 Diffuser Plug
8 Screw
9 Plug
10 Diffuser Insert
11 Safety Disc
12 Safety Disc Washer
13 Check (Poppet Valve)
14 Spring
15 Retainer
16 Retaining Ring
17 Gasket

Figure 1 Inflation Assembly (Bendix)

2991

List any defects discovered:

____

____

____

2. Note figure 2. Insert the end of a small paper clip in the slot in the side of the locking sleeve (3, figure 1) and raise the spring slip lock to release the locking sleeve.

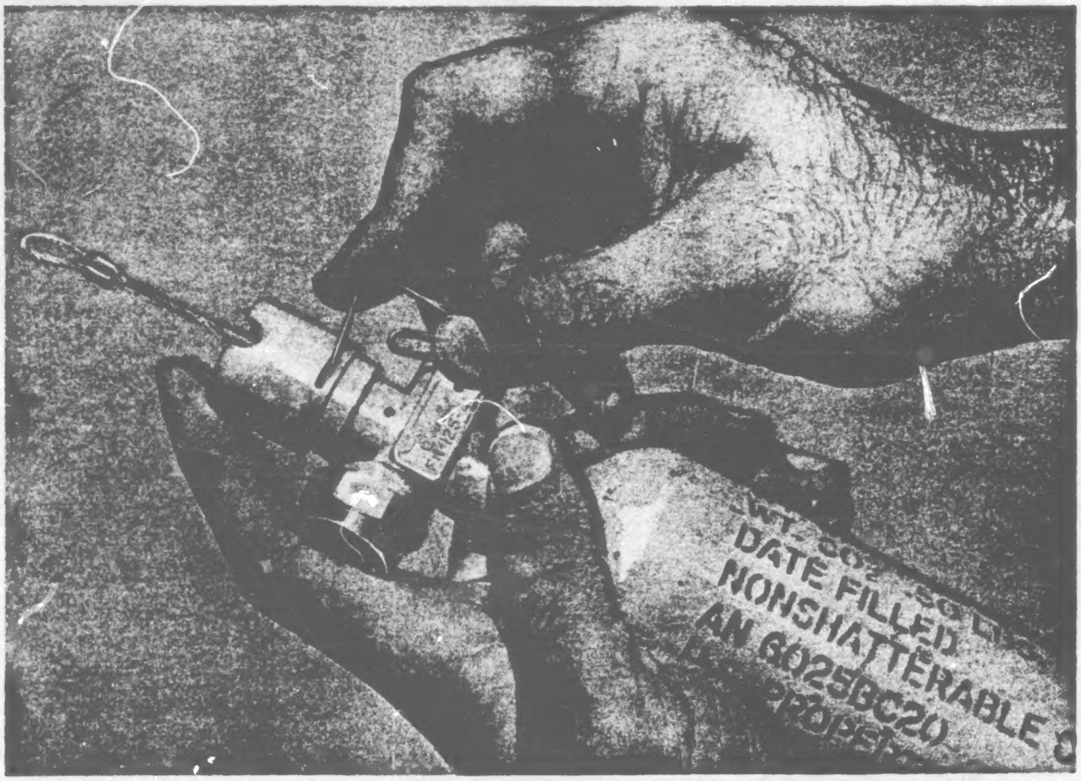


Figure 2. Releasing Spring on Locking Sleeve.

3. Lower the locking sleeve and remove the cable and ball assembly (4, figure 1).

4. Inspect the locking sleeve for nicks and for free up and down movement.

5. Inspect the cable assembly for fraying and a loosened ball on the end of the cable. List any defects discovered:

____

____

6. Note figure 3. Insert the metal rod provided into the cable ball hole of the cam and operate the cam to open the valve.

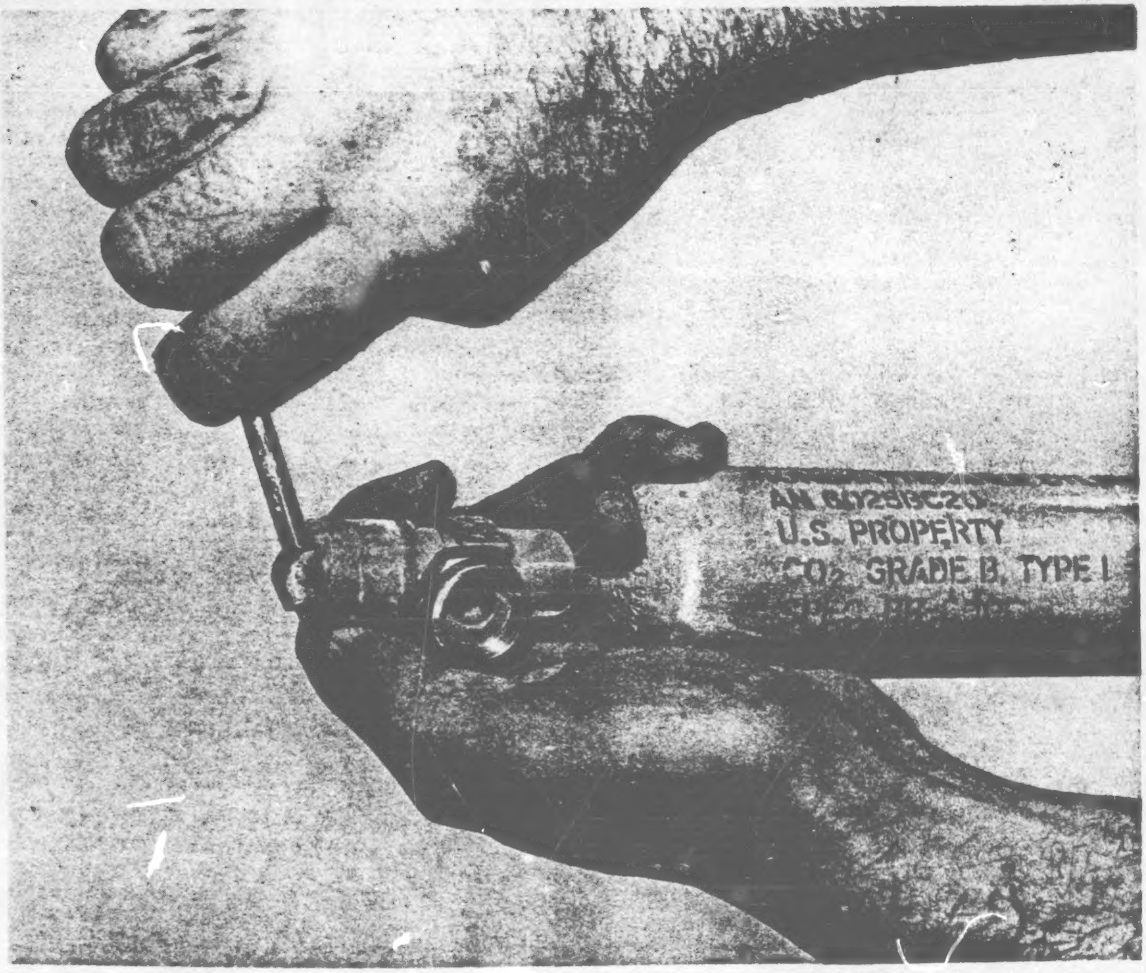


Figure 3. Operating Cam with Metal Rod.

Note: A charged cylinder can be discharged in this manner, or if the cylinder is overcharged during the charging operation, the metal rod is used to "bleed down" the cylinder to the proper weight in the event of an overcharge. The cam is also placed in this open position for charging the cylinder with CO_2.

7. Using the metal rod, operate the cam to the reset position.

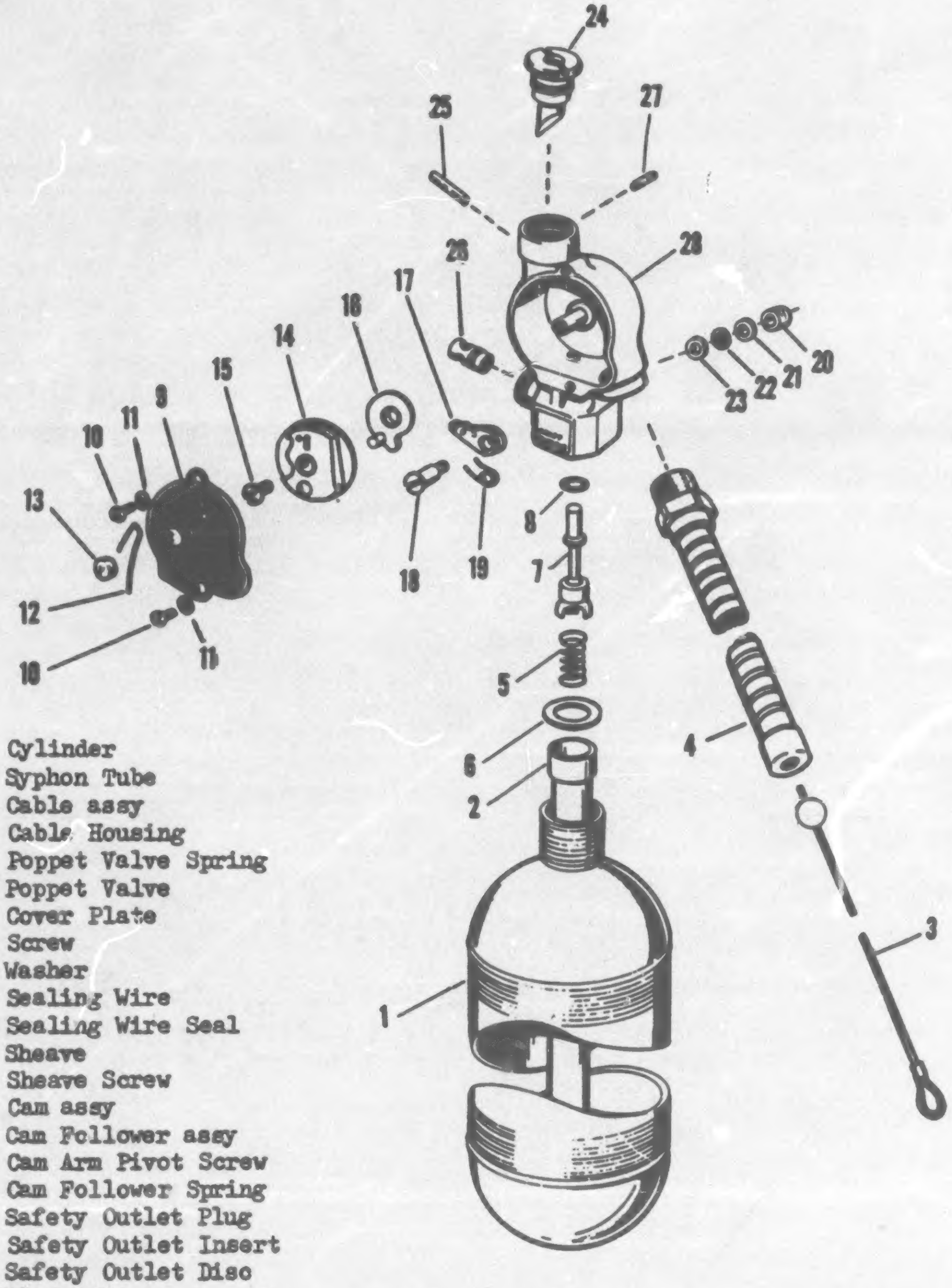
8. Replace the cable and ball assembly and raise the locking sleeve to the locked position.

Section II

INSPECTION AND OVERHAUL OF MULTIPLACE LIFE RAFT INFLATION CYLINDER ASSEMBLY

Refer to Figure 4 for an illustrated breakdown of the cylinder assembly.

2993


24
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2
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1
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20
21
22
23

1	Cylinder
2	Syphon Tube
3	Cable assy
4	Cable Housing
5	Poppet Valve Spring
7	Poppet Valve
9	Cover Plate
10	Screw
11	Washer
12	Sealing Wire
13	Sealing Wire Seal
14	Sheave
15	Sheave Screw
16	Cam assy
17	Cam Follower assy
18	Cam Arm Pivot Screw
19	Cam Follower Spring
20	Safety Outlet Plug
21	Safety Outlet Insert
22	Safety Outlet Disc
24	Plug assy
26	Deflector(Diffuser Plug)
28	Valve Body

Figure 4. Cylinder and Valve Assembly, Part Number 55C3689.

1. Using the cylinder assembly provided, remove the cover plate (9) from the valve assembly by removing the two screws (10) and washers (11).

2. Disengage the pull cable (3) from the sheave (14) and remove the sheave by removing the screw (15) which holds it in place.

3. Perform the following visual inspections of parts removed:

   a. Surfaces of valve parts for scratches, scoring, or dirt.

   b. Cover plate for loose rivets or damaged window.

   c. Sheave for burrs, cracks, or damage that would cause a malfunction.

   d. Pull cable for fraying and that the ball on the end of the cable is secure.

List any defects discovered:

____

____

____

4. Install the sheave, engaging the pin on the cam (16) into the hole in the sheave.

5. Install the sheave retaining screw.

6. Rotate the sheave to the charged position (all the way to the left). Charging pressure will automatically open the pilot valve.

Note: Final assembly will be completed after recharging of the cylinder.

Section III. CYLINDER RECHARGING

Warning: Any charged or partially charged gas cylinder of any size is potentially dangerous and must always be handled with caution. Handle all compressed gas cylinders carefully, never drop them or permit them to strike each other violently. Discharge valves of cylinders must not be bumped or knocked. Cylinders must be secured in a chain vise or other approved clamping device when being discharged. Protective gloves and a face mask or goggles must be worn throughout the cylinder charging process.

During your cylinder recharging procedure, refer to the diagram (figure 5) of the recharging set-up provided. For training purposes, all valves on the recharging set-up which are identified by letters on the diagram have been color coded. The instructor will inform you of the type of life raft that the cylinder you are recharging is used on.

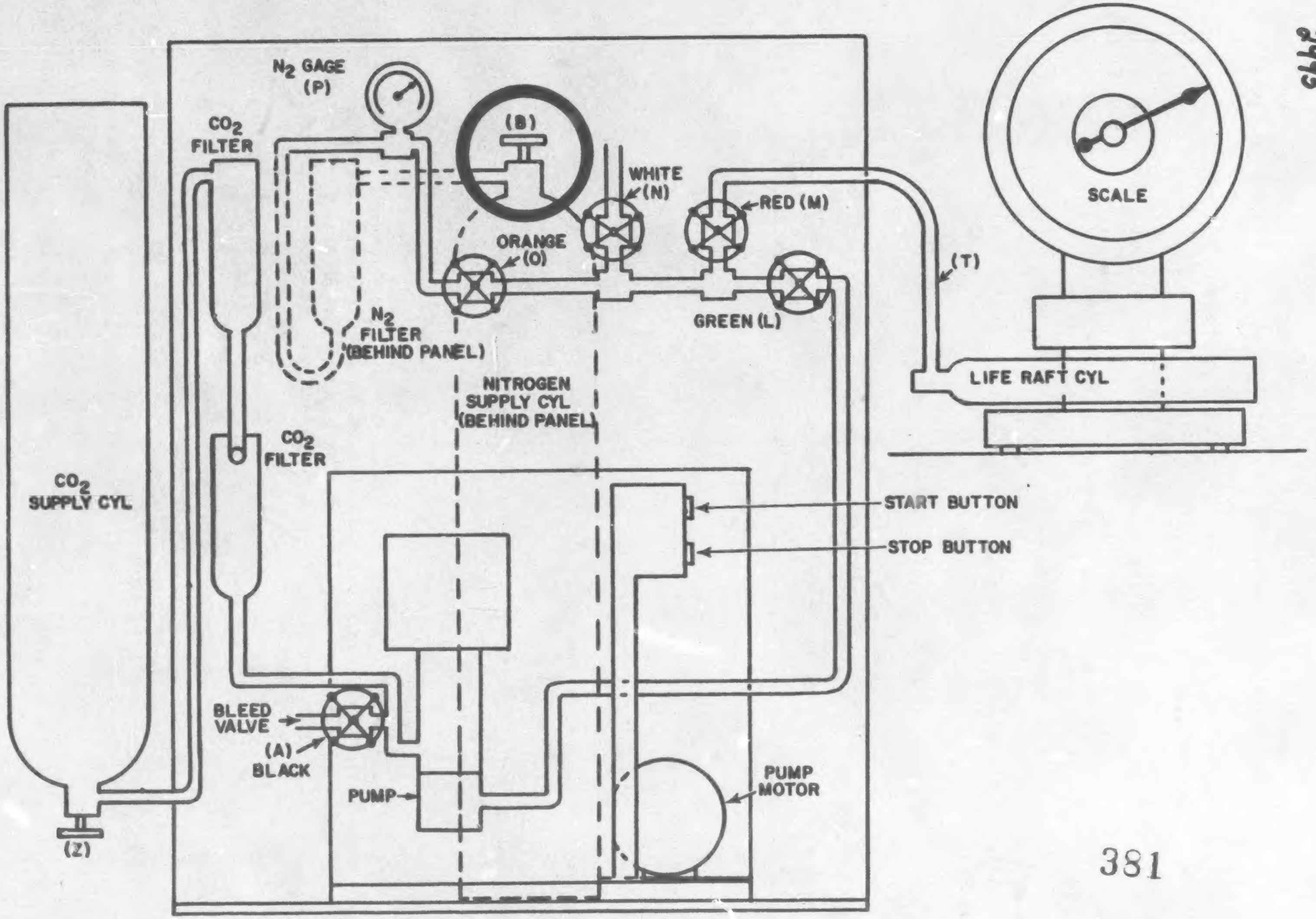

N$_2$ GAGE (P)
CO$_2$ FILTER
(B)
WHITE (N)
RED (M)
SCALE
ORANGE (O)
N$_2$ FILTER (BEHIND PANEL)
GREEN (L)
(T)
NITROGEN SUPPLY CYL (BEHIND PANEL)
LIFE RAFT CYL
CO$_2$ FILTER
CO$_2$ SUPPLY CYL
START BUTTON
STOP BUTTON
BLEED VALVE
(A) BLACK
PUMP
PUMP MOTOR
(Z)

Figure 5.

1. For what types of life rafts is this cylinder used? ____________

2. Note the empty weight of the cylinder assembly stenciled on the cylinder. The empty cylinder weight is ____________ lbs.

3. Place the cylinder in the holding adapter on the scale.

4. Make sure all valves on the recharging set-up are CLOSED.

5. Slowly open the valve (B) on the nitrogen supply cylinder by reaching through the opening in the top of the panel. Note that nitrogen supply pressure shows on the pressure gage (P). If it does not, consult your instructor. Does a reading show on the pressure gage? __________ (yes or no).

6. Open the ORANGE valve (O) in the nitrogen supply line.

7. Open the RED valve (M) in the cylinder charging line momentarily to purge air out of the charging hose (T).

8. Close the RED valve (M) and immediately connect the charging hose (T) to the cylinder to be charged. Use 2 wrenches to tighten the connection.

9. Unlock the scale mechanism by turning the handle below the dial to the left. Make sure the charging hose is freely suspended and does not rest on the equipment.

10. Set the scale to read exactly zero by carefully positioning the weight on the top balance bar of the scale. The zero line on the scale pointer should be exactly in line with the zero line on the scale dial.

11. Refer to table 1 and note the weight of N_2 to be added to the cylinder you are recharging. The specified weight of N_2 is ________ lb.

RAFT	CYL CAP(CU IN)	CO_2(LBS)	N_2(LBS)	COMBINED CHG
MA-1	147	2.98 ± .06	0.12 + .00 - .02	3.10 + .06 - .08
E-2B-LRU-1P	205	4.32 ± .06	0.12 ± .02	4.44 ± .08
F-2B	415	9.00 ± .062	0.20 ± .01	9.20 ± .072
F-2B(C121 ACFT ONLY)	386	9.00 ± 0.62	0.20 ± .01	9.20 ± .072

Table 1.

For the cylinder you are recharging, .1 lb of N_2 is within the tolerance allowed. Each graduation on the scale dial equals .1 of a pound. The scale may be read in hundredths of a pound by means of the vernier on the scale pointer. For a reading of .12 lb, the zero line on the pointer would be just past one graduation on the scale dial and the second line on the vernier would be in line with a graduation on the scale dial.

2997

12. While watching the pointer on the scale, slightly open the RED valve (M) and when the pointer has moved one graduation on the scale dial, CLOSE the valve.

If a cylinder is overcharged with N_2 or CO_2, it must be bled down to the proper weight by placing a screwdriver in the slot in the sheave and carefully rotating the sheave clockwise.

13. Close the valve (B) on the N_2 supply cylinder.

14. Open the WHITE bleed valve (N) to bleed nitrogen pressure from the line, then close the valve.

15. Close the ORANGE valve (O) in the nitrogen supply line.

16. Again refer to table 1 and determine the weight of CO_2 for the cylinder you are recharging. The specified weight of CO_2 is __________ lbs. Although the specified weight is given in pounds and hundredths of pounds, a reading to the nearest .1 of a pound is well within tolerance. For the MA-1 raft cylinder your CO_2 weight will be 3.0 lbs. For the E-2B-LRU-1P raft cylinder your CO_2 weight will be 4.3 lbs.

17. Reset the scale to read exactly zero by repositioning the weight on the top balance bar.

18. Slowly open the valve (Z) on the CO_2 supply cylinder.

19. Crack open the BLACK bleed valve (A) at the pump inlet until liquid CO_2 is flowing freely from the supply cylinder, then close the valve. The dehydrator filters must first fill with liquid CO_2.

20. Open the GREEN valve (L) in the pump outlet line.

21. Crack open the WHITE bleed valve (N) which will allow CO_2 gas to be purged from the pump. Close this valve as soon as liquid CO_2 appears or gas no longer flows.

22. Open the RED valve (M) in the cylinder charging line.

23. Insert the plug on the power cable into the electrical power outlet. Read the following caution and steps 23 and 24, then start the recharging unit by pressing the START button.

Caution: You must stop the pump before closing the RED or GREEN valves in the outlet charging line from the pump. Failure to do so may result in blowing the safety rupture disc at the pump outlet.

24. Carefully watch the scale and when it reads the weight of CO_2 to be added, quickly press the STOP button to stop the recharging unit.

25. As soon as the pump stops, close the GREEN valve (L) in the pump outlet line.

26. Close the valve (Z) on the CO_2 supply cylinder.

27. Open the WHITE bleed valve to bleed CO_2 pressure from the line.

28. Lock the scale mechanism by turning the handle below the dial to the right.

29. Using two wrenches, slowly loosen the hose adapter connection at the life raft cylinder and disconnect the hose from the adapter.

30. Remove the cylinder from the scale.

31. Unplug the power cable from the electrical power outlet and secure the cable.

Section IV. FINAL CYLINDER ASSEMBLY - Refer to Figure 4

1. Note figure 6. Slide the pull cable through the pull cable housing and wrap it around the sheave, engaging the ball in the recess of the sheave for the DOWN PULL position.

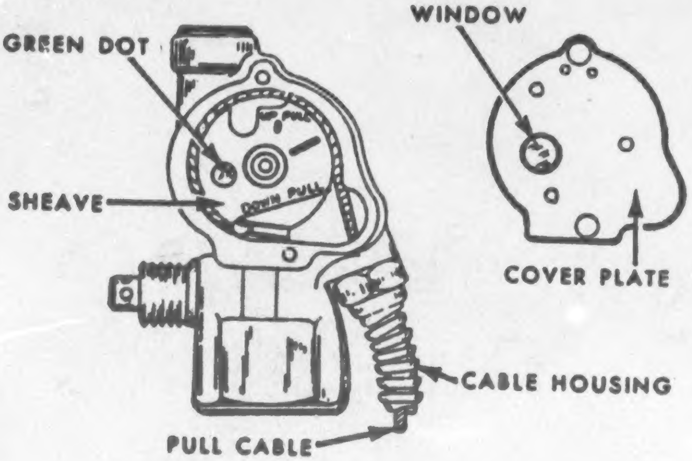


Figure 6.

Note the small hole through the top edge of the sheave for installing a piece of copper safety wire. Note figure 7. The two ends of the safety wire are passed up through the two small holes in the cover plate, wrapped around a cover plate screw, and sealed with a lead seal. This safety wire is broken when the cable is pulled to discharge the cylinder.

2999

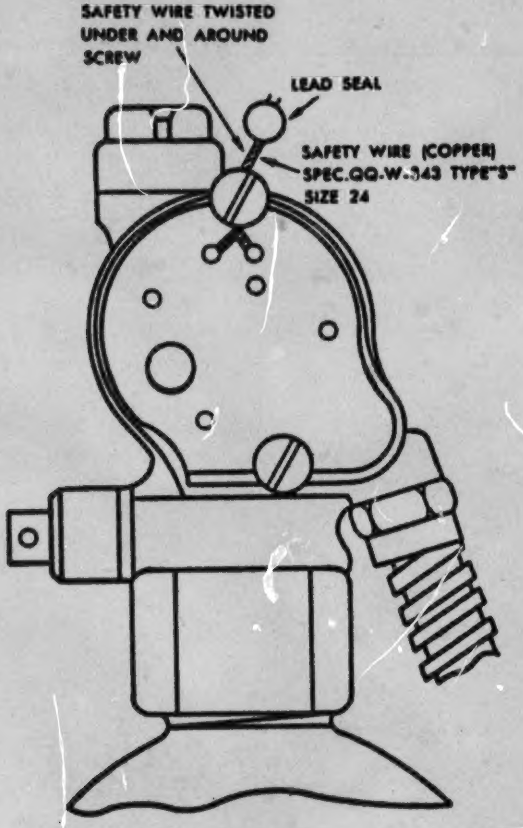

SAFETY WIRE TWISTED UNDER AND AROUND SCREW
LEAD SEAL
SAFETY WIRE (COPPER) SPEC.QQ.W-343 TYPE"S" SIZE 24

Figure 7. Multiplace Control Head.

Caution: Note the under side of the valve cover plate. Modified cover plates have a leaf spring installed inside the flange on the cover plate to ensure that the pull cable remains in place around the sheave. When installing the modified cover plate, first rotate it to the right approximately 40 degrees in order for the projecting end of the spring to clear the sheave.

2. Assemble the cover plate (9) to the valve body (28) with the washers (11) and screws (10). Make sure the green indicator dot is visible through the window in the cover plate.

385

PROGRAMMED TEXT

3ABR42331-PT-406

Technical Training

Aircraft Environmental Systems Mechanic

AIRCRAFT FIRE EXTINGUISHING LIQUID AGENT SYSTEMS

24 November 1978

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.
Do Not Use on the Job.

386

3001

FOREWORD

This programmed text was prepared for use in the 3ABR42331 instructional system. The material contained herein has been validated using 45 students enrolled in the 3ABR42331 course. Ninety percent of the students taking this text surpassed the criterion called for in the approved lesson objective. The average student required (33) minutes to complete the text.

OBJECTIVES

After completing this programmed text, you will be able to:

1. Associate four (4) of five (5) components of the five extinguishing directional system with their purpose.

2. Select the safety precautions, without error, involved in handling fire extinguishing agents.

INSTRUCTIONS

This programmed text presents material in small steps called "frames." After each frame you will find a number of statements and you are asked to select the statement or statements that are true. Read the material in each frame before making a selection. The answers to each frame can be found on the top of the following page. If you select the correct answers, continue to the next frame. If you are wrong or in doubt, read the material again and correct yourself before proceeding.

Supersedes 3ABR42231-PT-305A, 14 July 1971.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 600; TTVSA - 1

It should be stated here that fires aboard an aircraft are not too common. Some aircraft have no fire extinguishing system at all. The B-52, for example, has a fire detection system or fire warning system, but no extinguishing system. Aircraft that do have a fire extinguishing system use it only in case of an emergency, after every attempt has been made to extinguish the fire.

Model F-Eleventeen Fire Extinguishing System.

Model F-Eleventeen Fire Extinguishing System.

Select the following statement(s) that is/are true.

_____1. The fire extinguishing system is used only when all other attempts to put out the fire have failed.

_____2. All aircraft have fire extinguishing systems.

3003

Answers to Frame 1: 1. _T_ 2. ___

Frame 2

In the past, the Air Force has experimented with several fire extinguishing agents. For years, carbon dioxide (CO_2), was the chemical they depended upon. But CO_2 cylinders are heavy and hold surprisingly little gas for the space they occupy. Also, many pilots saw the flames continue after they had used the whole load of CO_2. So the engineers looked for an easily vaporized extinguishing liquid that would allow the aircraft to carry more potential gas in the small space available. In experimenting with chemical compounds, they came up with the following liquid agents. Chloro-bromo-methane (CB), Bromo-tri-fluoro-methane (BT), and Di-bromo di-fluoro-methane (DB). Like CO_2, these agents exclude oxygen from the burning area.

Select the following statement(s) that is/are true.

_____ 1. CO_2 has been the main fire extinguishing agent for years.

_____ 2. CO_2 is not too effective for aircraft use.

_____ 3. Chlorobromomethane is a liquid agent.

_____ 4. Like CO_2, the liquid agents remove the oxygen from the burning area.

_____ 5. CO_2 is a liquid fire extinguishing agent.

Answers to Frame 2: 1. T 2. T 3. T 4. T 5. ___

Frame 3

Of the three liquid agents listed in the previous frame, the one most used is Chlorobromomethane, or more commonly known as "CB." It will be referred to as CB in this text. CB is a heavy, colorless liquid that will evaporate from an open container faster than alcohol, but slower than ether. It produces a gas dense enough to displace most of the oxygen in the area. CB is effective on all types of fires. It will do just as much as a large cylinder of CO_2 or soda acid.

Select the following statement(s) that is/are true.

_____1. Chlorobromomethane is commonly called "CB."

_____2. CB is a heavy, colorless liquid.

_____3. CB will evaporate faster than alcohol.

_____4. When CB evaporates, it produces a very dense gas.

_____5. CB is effective on all types of fires.

_____6. When CB is released, it displaces most of the oxygen in the area.

3005

Answers to Frame 3: 1. T 2. T 3. T 4. T 5. T 6. T

Frame 4

CB begins to boil at 154° F and produces the dense gas previously described. This is a very low boiling point for a liquid considering that water boils at 212° F. CB will freeze and become a solid at -123° F. Although CB evaporates readily, it has very little compressibility when stored in a container. Therefore, CB fails to produce enough gas pressure to expel the liquid from the container when an opening is provided. To produce the required gas pressure to discharge the CB, a nitrogen gas (N_2) is added. Nitrogen was chosen as the expellant because it is not greatly affected by temperature changes. The effective discharge pressure for a CB system is 400 to 440 PSI which is obtained by using the nitrogen. Also, by using nitrogen, the CB containers will operate satisfactorily anywhere between -67° F and +160° F.

Select the following statement(s) that is/are true.

_____1. Nitrogen is added to expel the CB from the container.

_____2. CB will boil at a very low temperature (154° F).

_____3. CB produces enough gas pressure by itself for expelling purposes.

_____4. The effective pressure required to expel CB is 400 to 440 psi.

_____5. With the addition of nitrogen, the CB containers will operate satisfactorily anywhere between -67° F and +160° F.

_____6. CB will begin to boil at a very high temperature.

_____7. CB has very little compressibility when stored in the container.

Answers to Frame 4: 1. T 2. T 3. ___ 4. T
5. T 6. ___ 7. T

Frame 5

The CB used in a fire extinguishing system is actually a mixture of several chemicals. Only 82% of this mixture is pure chlorobromomethane. For technical reasons, there is also 9% methylene bromide and 9% methylene chloride added to complete the mixture. These are also clear, heavy liquids with properties much like CB. However, they are highly corrosive chemicals and when mixed with water or water vapor, form hydrochloric acid. Hydrochloric acid is highly corrosive; in fact, contractors use it to clean bricks. Since the fire extinguishing system discharge nozzles at the engines are open to the atmosphere, it is almost impossible to keep water out of the system. An inhibitor (preventive) is added to the CB to reduce corrosion and prevent damage to the aluminum tubing.

Select the following statement(s) that is/are true.

_____1. The CB mixture used contains 82% pure CB.

_____2. Methylene bromide and methylene chloride are high corrosive chemicals.

_____3. Hydrochloric acid is not corrosive.

_____4. An inhibitor is added to the CB mixture to reduce corrosion.

_____5. CB is actually 82% pure CB, 9% methylene bromide and 9% methylene chloride.

_____6. Without an inhibitor, CB and water will form hydrochloric acid.

3007

Answers to Frame 5: 1. T 2. T 3. ___ 4. T 5. T 6. T

Frame 6

As previously stated, CB is effective on all types of fires and, since it has an inhibitor, it will not ruin the very materials you are trying to save from the fire. The main advantage that CB has over fire extinguishing agents that were previously used, is that it takes less CB to extinguish the same fire. In other words the covolume (agent versus oxygen by volume) of CB is 15%. The covolume of CO_2 is 45 percent, and water is 67 percent. Simply stated, on a given fire, you would have to cover 67% of the area with water, 45% with CO_2 and only 15% with CB to extinguish the fire by removing the oxygen.

Select the following statement(s) that is/are true.

_____1. The covolume of CB is 15 percent.

_____2. It takes more CB to put out a given fire than water.

_____3. Covolume refers to the amount of agent required to displace a given amount of oxygen by volume.

_____4. CB will not ruin the items you are trying to save from the fire.

_____5. CB is effective on all types of fires.

Answers to Frame 6: 1. T 2. ___ 3. T 4. T 5. T

Frame 7

CB is the liquid agent most commonly used, the other two liquids should be mentioned. Bromo-tri-fluoro-methane, or more commonly known as "BT," and Di-bromo-di-fluoro-methane, which is known as "DB," are heavy, colorless liquids like CB and for all practical purposes, have the properties and characteristics of CB. However, the vapors produced by BT and DB are more toxic (poisonous) than those of CB. The same aircraft containers, system components, and recharging set-up is used with all three liquid agents. The only requirement is that all components have to be thoroughly cleaned when changing from one agent to another.

Select the following statement(s) that is/are true.

_____1. The characteristics of CB, BT, and DB are much the same.

_____2. The vapors produced by BT and DB are more toxic than those of CB.

_____3. Different containers are used for all three agents.

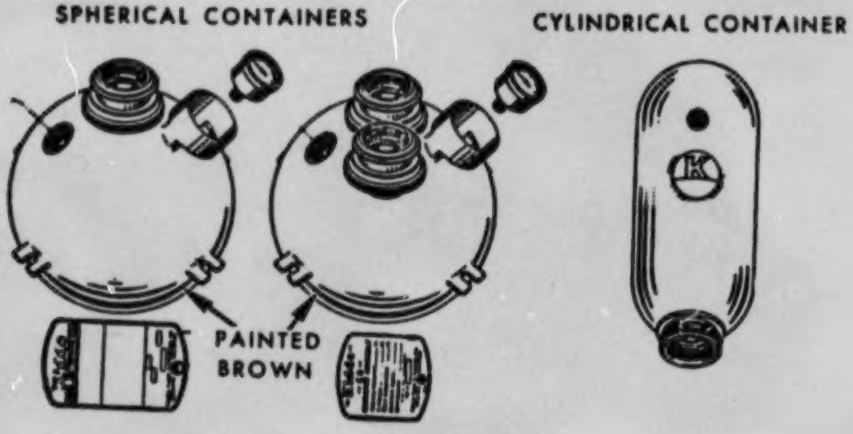
_____4. Dibromodifluoromethane is commonly called DB.

3009

Answers to Frame 7: 1. T 2. T 3. ___ 4. T

Frame 8

The containers used to store CB on the aircraft are generally spherical (round), but can be cylindrical. (See illustration below). The size of the containers will vary with the needs of a particular aircraft. At the present time, containers are made that hold anywhere between 8 and 33 pounds of CB. They are filled by weight. The containers are made of steel and painted brown to indicate that it contains a liquid fire extinguishing agent. Remember, each container is charged with 400 to 440 psi of nitrogen in addition to the specific weight of CB.



CB CONTAINERS

Select the following statement(s) that is/are true.

_____1. CB containers are filled by weight.

_____2. All aircraft CB containers are cylindrical.

_____3. CB containers are made that hold anywhere between 8 and 33 pounds.

_____4. Each container is charged with 400 to 440 psi of nitrogen.

_____5. CB containers are painted brown.

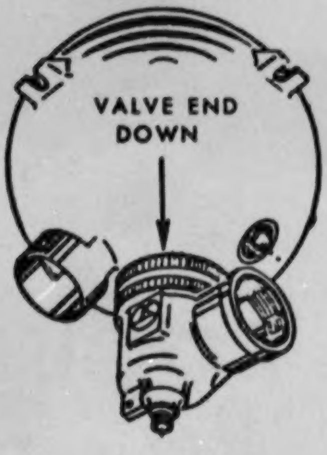
_____6. CB containers are made of aluminum.

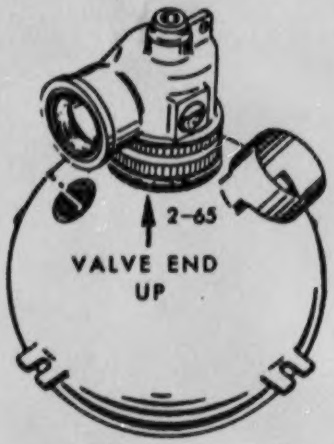
Answers to Frame 8: 1. T 2. ___ 3. T 4. T 5. T 6. ___

Frame 9

CB containers or spheres are manufactured by two different companies, Walter Kidde and American-LaFrance. The containers made by Walter Kidde have no siphon tube and must be mounted valve end down. American-LaFrance containers have a siphon tube and are mounted valve end up in the aircraft. Proper positions of the two types of containers are shown below. Unlike CO_2 cylinders, CB containers do not require a hydrostatic test every five years. However, if an aircraft container is to be shipped fully charged through interstate commerce channels, it must be tested or have been tested within the past 5 years. The last hydrostatic test date (if performed) can be found on the valve end of the container. It will be stamped in the metal. The last test date is shown in the following manner, 1-65 or 2-65. This indicates the test was performed in the first half or second half of 1965.

WALTER KIDDE





AMERICAN-LAFRANCE

Select the following statement(s) that is/are true.

_____1. The containers made by Walter Kidde are mounted valve end down.

_____2. CB containers are removed from the aircraft for a hydrostatic test every five years.

_____3. American-LaFrance containers have a siphon tube.

_____4. CB containers require a hydrostatic test only if they are shipped fully charged.

_____5. Walter Kidde containers have no siphon tube.

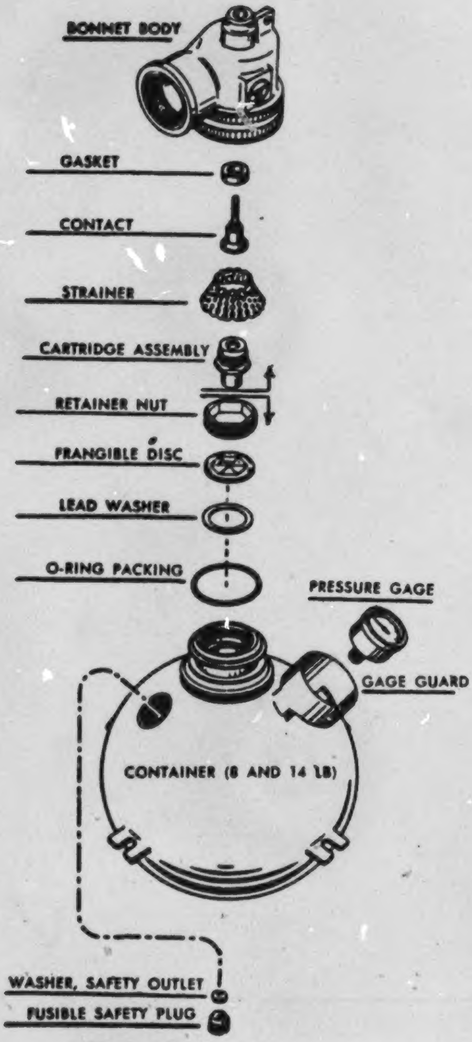
_____6. If the figure 1-60 is stamped on the valve end of a CB container, it was tested the first half of 1960.

3011

Answers to Frame 9: 1. T 2. ___ 3. T 4. T 5. T 6. T

Frame 10

In the illustration we have a CB container and bonnet assembly. The bonnet assembly includes the bonnet body, gasket, contact, strainer and cartridge assembly. The explosive cartridge (or squib) is fired by 28 VDC and ruptures the frangible disc. The frangible disc, lead washer and O-ring packing is held in place in the container outlet by the retainer nut. The frangible disc is undercut into pie-shaped segments so it will break clean when hit by the slug from the cartridge. The strainer in the bonnet will catch the segments from the frangible disc to prevent them from going out into the system with the agent and obstructing flow. The fusible plug in the safety outlet will blow if thermal expansion causes too much pressure to build up in the container. The pressure gage is provided to indicate internal pressure.


BONNET BODY
GASKET
CONTACT
STRAINER
CARTRIDGE ASSEMBLY
RETAINER NUT
FRANGIBLE DISC
LEAD WASHER
O-RING PACKING
PRESSURE GAGE
GAGE GUARD
CONTAINER (8 AND 14 LB)
WASHER, SAFETY OUTLET
FUSIBLE SAFETY PLUG

CB container and bonnet assembly.

Select the following statement(s) that is/are true.

_____1. The cartridge is part of the bonnet assembly.

_____2. The frangible disc holds the agent in the container.

_____3. The fusible safety plug takes care of thermal expansion.

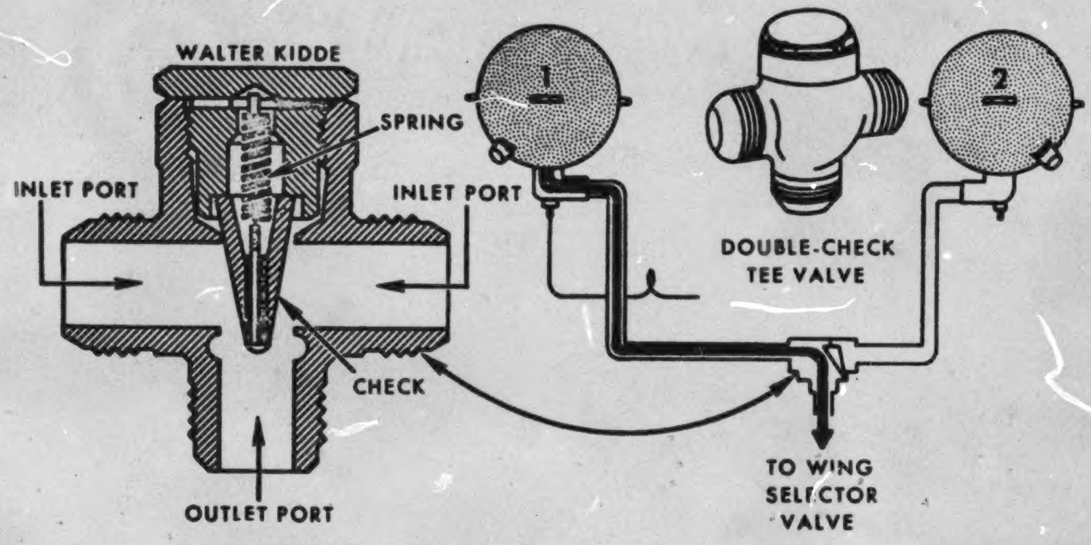
_____4. The cartridge is fired by 110 VAC current.

_____5. A slug from the cartridge breaks the frangible disc.

Answers to Frame 10: 1. T 2. T 3. T 4. ___ 5. T

Frame 11

The Walter Kidde double-check tee valve, illustrated below connects two supply lines or inlet ports to a common distribution line or outlet port. The double-check tee valve operates when CB pressure pushes the flapper (or check) to one side, closing off either inlet port depending on which CB container is discharged. When the flow of CB is completed, a spring returns the flapper to its original (center) position. The purpose of the double-check tee valve, is to prevent a full CB container from entering one that has already been discharged. For example, suppose the No. 2 container in the illustration below had to be discharged after the No. 1 container was empty. Without the double-check tee valve, the No. 2 container would discharge into the empty No. 1 container.



DOUBLE-CHECK TEE VALVE

Select the following statement(s) that is/are true.

_____1. CB pressure positions the double-check tee valve.

_____2. The double-check tee valve is solenoid operated.

_____3. The double-check tee valve prevents the agents from flowing into an empty container.

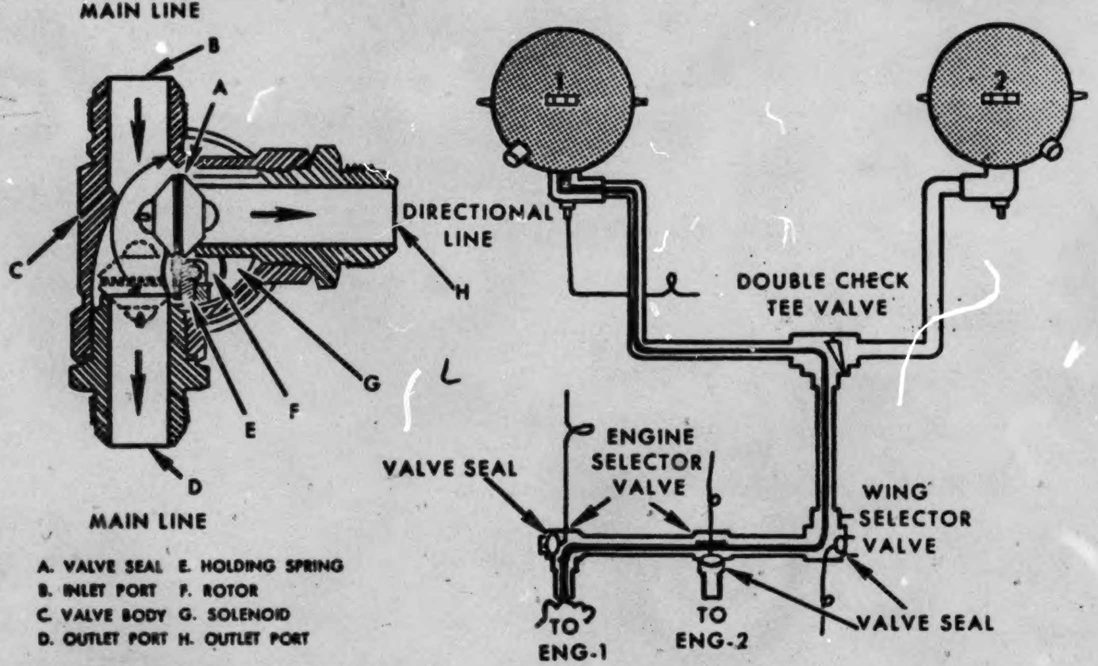
_____4. The flapper or check is spring loaded to the center position.

3013

Answers to Frame 11: 1. T 2. ___ 3. T 4. T

Frame 12

Two-way directional valves or selector valves used in the fire extinguishing system are solenoid operated as shown in the illustration. In most cases the selector valves are controlled by fire switches on the flight engineer's panel or pilot's panel. When a fire warning light comes on, the directional valves are positioned by switches in such a way as to direct the agent to the engine nacelle which has the fire. In the normal position, the engine selector valves close the line going to each engine. Note that ENG-2 selector valve is closed and ENG-1 selector valve is energized open and agent is flowing to that engine. In the schematic on the left below, when solenoid (G) is energized, the valve seal (A) is pivoted on the rotor (F) to close outlet port (H) as shown. The holding spring (E) normally holds the valve seal (A) over outlet port (D).


MAIN LINE
B
A
C
DIRECTIONAL LINE
H
G
F
E
D
MAIN LINE
A. VALVE SEAL E. HOLDING SPRING
B. INLET PORT F. ROTOR
C. VALVE BODY G. SOLENOID
D. OUTLET PORT H. OUTLET PORT
1
2
DOUBLE CHECK TEE VALVE
ENGINE SELECTOR VALVE
VALVE SEAL
WING SELECTOR VALVE
VALVE SEAL
TO ENG-1
TO ENG-2

TWO-WAY DIRECTIONAL VALVE

Select the following statement(s) that is/are true.

_____1. Directional valves are also called selector valves.

_____2. Directional valves are solenoid operated.

_____3. Directional valves direct the flow of the extinguishing agent.

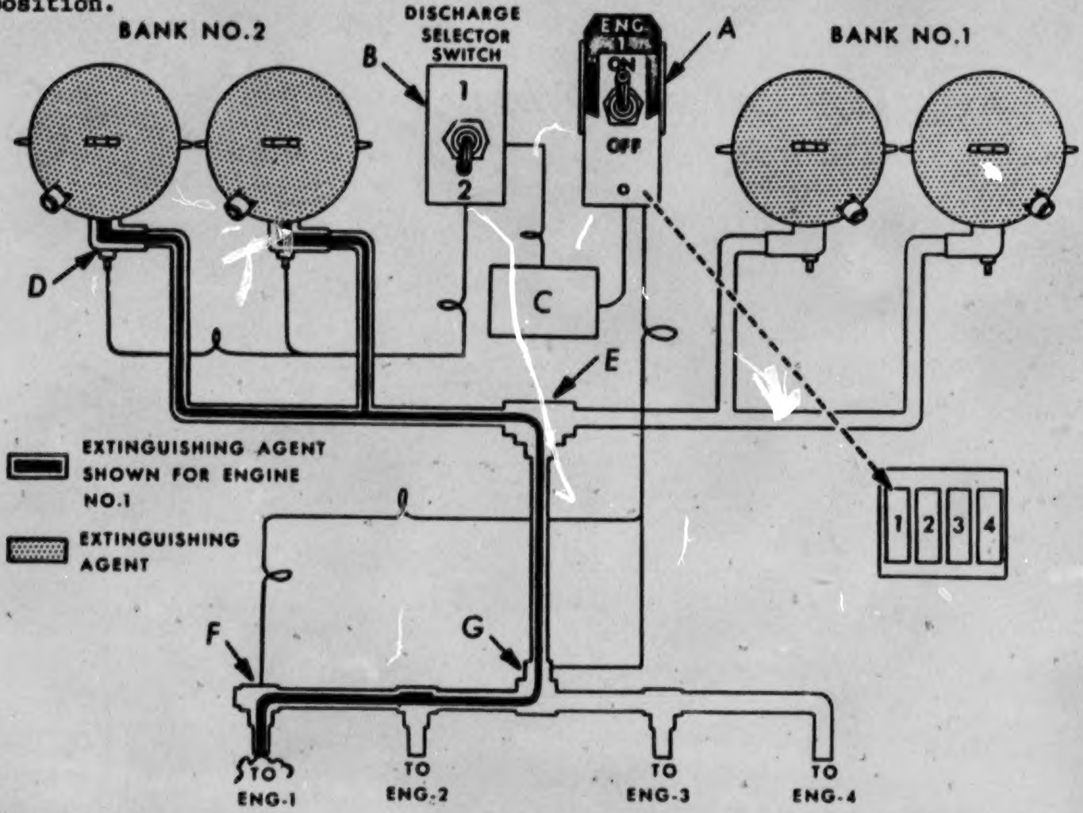
_____4. Directional valves are held in one position by a spring.

_____5. The double-check tee valve and directional valve operate the same.

Answers to Frame 12: 1. T 2. T 3. T 4. T 5. ___

Frame 13

Shown below is a typical CB fire extinguisher system. This is a two-shot system, in that BANK NO. 1 or BANK NO. 2 can be discharged to the same engine as selected by the discharge selector switch (B). As illustrated below, CB is being discharged into ENG-1 nacelle. Let's follow the sequence of events that led up to this action. When the engine NO. 1 fire light came on, the engineer first shuts off fuel, bleed air, and hydraulic fluid to that engine. If the fire still exists he positions the discharge selector switch (B) to BANK NO. 2 and places the ENG 1 selector switch (A) "on". (A selector switch is provided for each engine.) The cartridge in the bonnet assembly (D) on both containers of BANK NO. 2 now receive current. The ENG-1 selector switch (A) positions the wing directional valve (G) and engine selector valve (F) for ENG-1. The time delay relay (C) will delay current to the cartridge in either bank for about two seconds to give the directional valves time to position. If the fire is still not out, BANK NO. 1 can be discharged to the same engine by moving the discharge selector switch to BANK NO. 1 position.



Typical CB Fire Extinguisher System.

Select the following statement(s) that is/are true.

_____1. The above system is referred to as a two-shot system.

_____2. The engine selector switch positions the wing and engine selector valves.

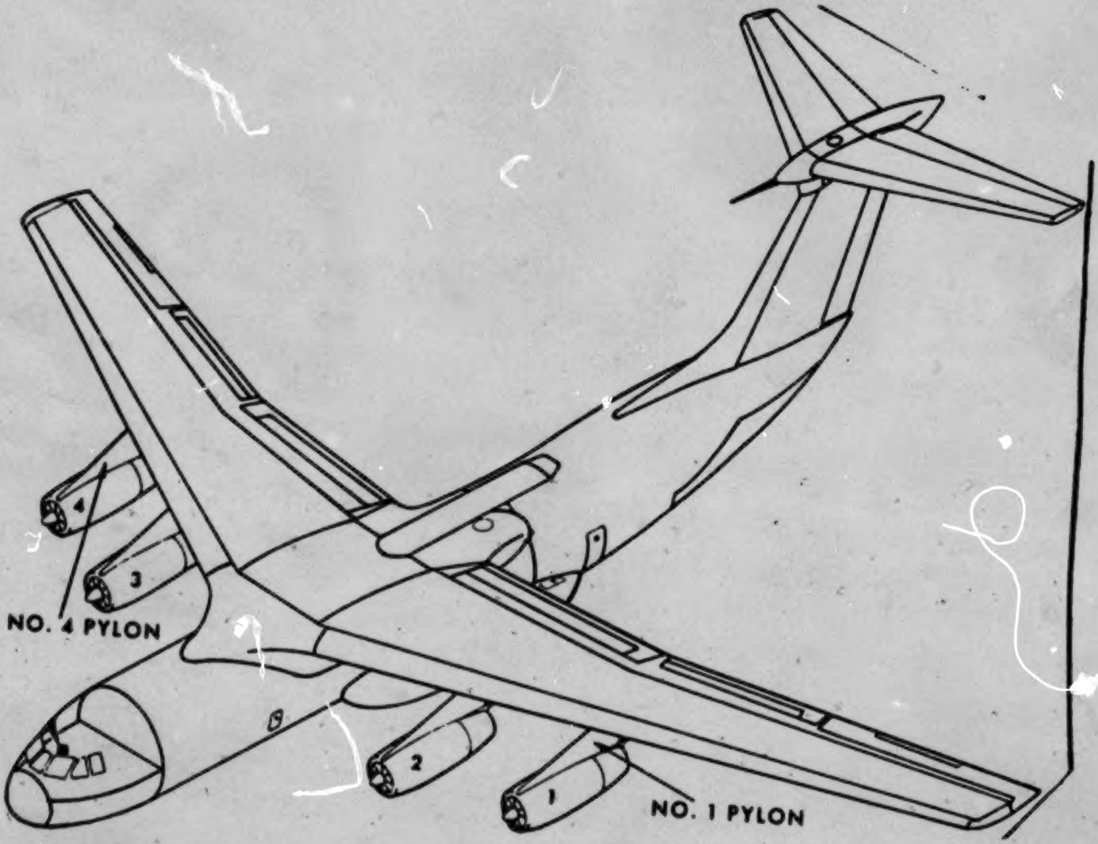
_____3. The discharge selector switch determines which bank is to be used.

_____4. The time delay relay allows the directional valves to position before releasing the agent.

Answers to Frame 13: 1. T 2. T 3. T 4. T

Frame 14

Let's discuss the fire extinguishing system that is used on the aircraft shown below. This system uses Di-bromo-di-fluoro-methane or DB as the extinguishing agent. The DB containers (or bottles) are installed in the NO. 1 and NO. 4 engine pylons. NO. 1 pylon has a two containers which are used for engines 1 and 2. NO. 4 pylon has two containers for engines 3 and 4. Operation of this system differs from the typical CB system previously discussed (Frame 12). In a typical system, the emergency shutdown system must be used before the fire extinguishing system is operated. On this aircraft, the fire extinguishing system and engine emergency shutdown system are combined. In other words, provisions for isolating each engine from fuel, bleed air and hydraulic fluid is combined with the fire extinguishing system.



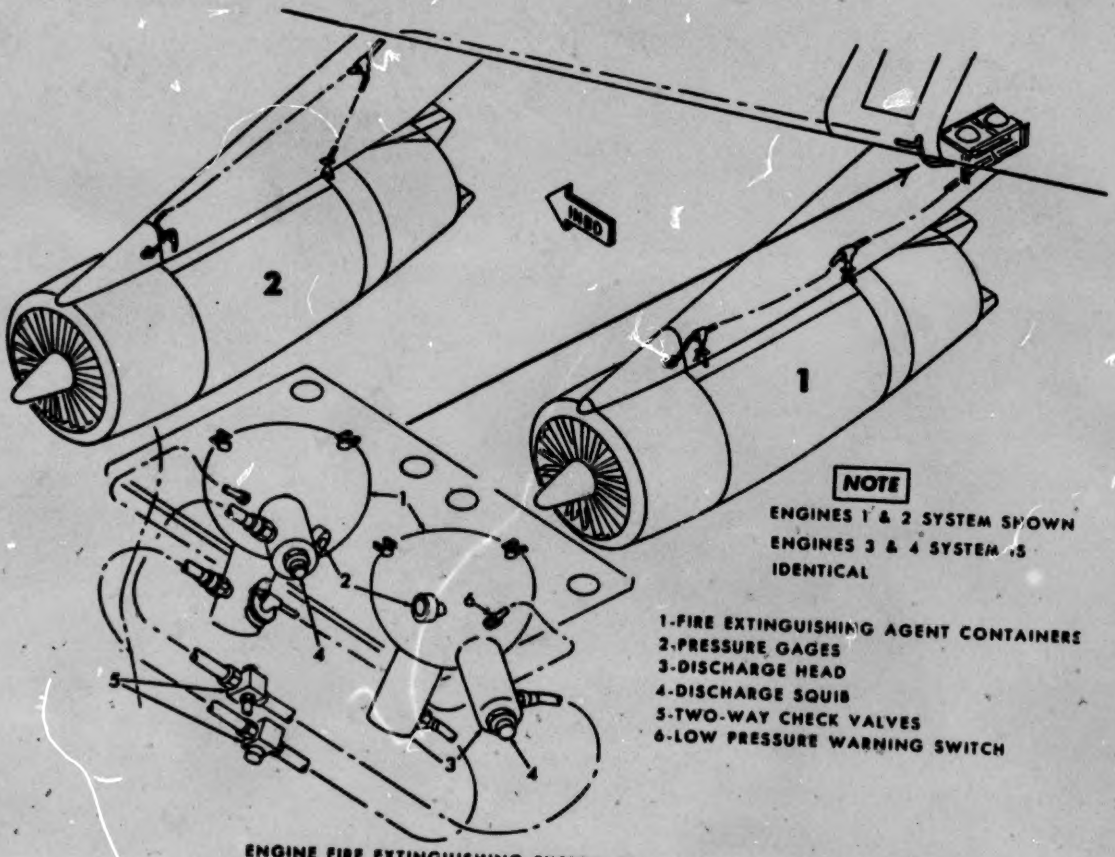
Select the following statement(s) that is/are true.

_____ 1. The fire extinguishing system on the aircraft shown above uses DB.
_____ 2. The DB containers are installed in NO. 1 and NO. 4 engine pylons.
_____ 3. On this aircraft the engine emergency shutdown system is combined with the fire extinguishing system.

Answers to Frame 14: 1. T 2. T 3. T

Frame 15

Shown below are the components of the engine fire extinguishing system on the aircraft. Number 4 engine pylon has identical components for engines 3 and 4. Note that each agent container (1) has two discharge heads (3). The discharge head is similar to the bonnet assembly previously discussed. Pressure gages (2), discharge squib (4), and two-way check valves (5) have also been discussed. When bottle pressure drops below 225 psi or when a bottle is discharged, a low pressure warning switch (6) on each bottle turns on a light on the pilots instrument panel.


INBD
2
1
NOTE
ENGINES 1 & 2 SYSTEM SHOWN
ENGINES 3 & 4 SYSTEM IS IDENTICAL
1
2
4
5
6
3
4
1-FIRE EXTINGUISHING AGENT CONTAINERS
2-PRESSURE GAGES
3-DISCHARGE HEAD
4-DISCHARGE SQUIB
5-TWO-WAY CHECK VALVES
6-LOW PRESSURE WARNING SWITCH

ENGINE FIRE EXTINGUISHING SYSTEM COMPONENTS LOCATIONS

Select the following statement(s) that is/are true.

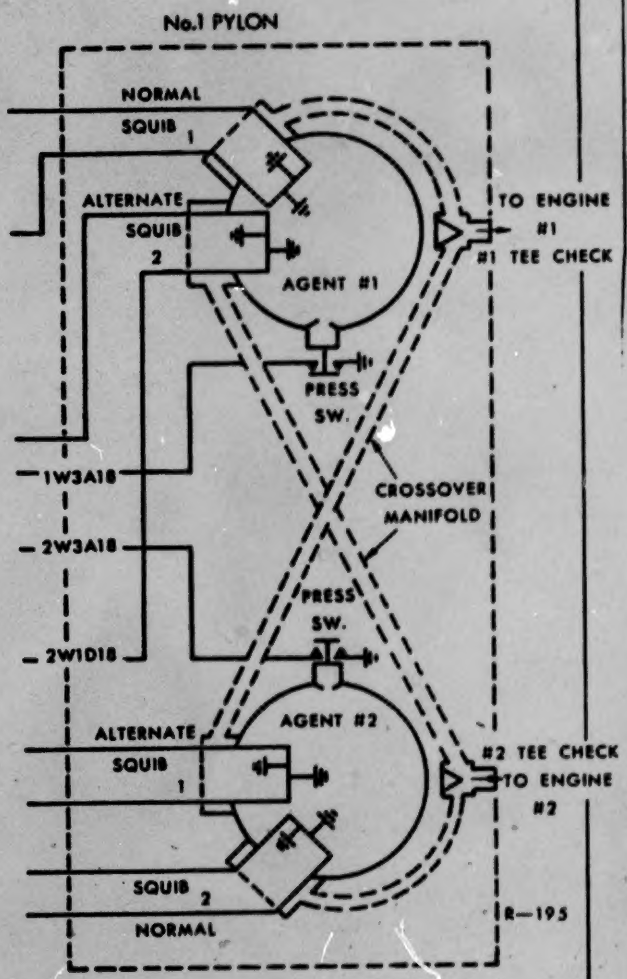
____1. The DB bottles in the system have two discharge heads.
____2. The engine fire extinguishing components are in NO. 2 and NO. 3 pylons.
____3. Each DB bottle in this system has a low pressure warning switch.
____4. The discharge squib is an explosive device like a cartridge.

3017

Answers to Frame 15: 1. T 2. ___ 3. T 4. T

Frame 16

Let's take a look at the components in NO. 1 pylon and the controls for these components. Note that this system does not have directional valves as we discussed in the typical CB system. The agent is directed by the NORMAL or ALTERNATE discharge head on each bottle. Look at agent #1 bottle (top bottle) in the schematic. Note that squib #1 is installed in the normal discharge head on this bottle. If squib #1 is fired, the agent will go out the normal discharge head and through the tubing to engine NO. 1. If squib #2 in the alternate discharge head of this bottle is fired, the agent will go down to the #2 tee check valve and out to the NO. 2 engine. Note that both bottles are connected with a crossover manifold. In bottle NO. 2 (agent #2) the normal discharge head sends the agent to engine NO. 2 and the alternate discharge head sends the agent up to the #1 tee check valve to NO. 1 engine. The components in NO. 4 pylon are identical to these.


No.1 PYLON
NORMAL
SQUIB 1
ALTERNATE
SQUIB 2
AGENT #1
TO ENGINE #1
#1 TEE CHECK
PRESS SW.
CROSSOVER MANIFOLD
1W3A18
2W3A18
2W1D18
PRESS SW.
AGENT #2
ALTERNATE
SQUIB 1
#2 TEE CHECK
TO ENGINE #2
SQUIB 2
NORMAL
R—195

Select the following statement(s) that is/are true.

_____1. In agent #1 bottle, the normal discharge head sends agent to NO. 1 engine.

_____2. In agent #2 bottle, the alternate discharge head sends agent to NO. 1 engine.

_____3. A crossover manifold connects both DB bottles.

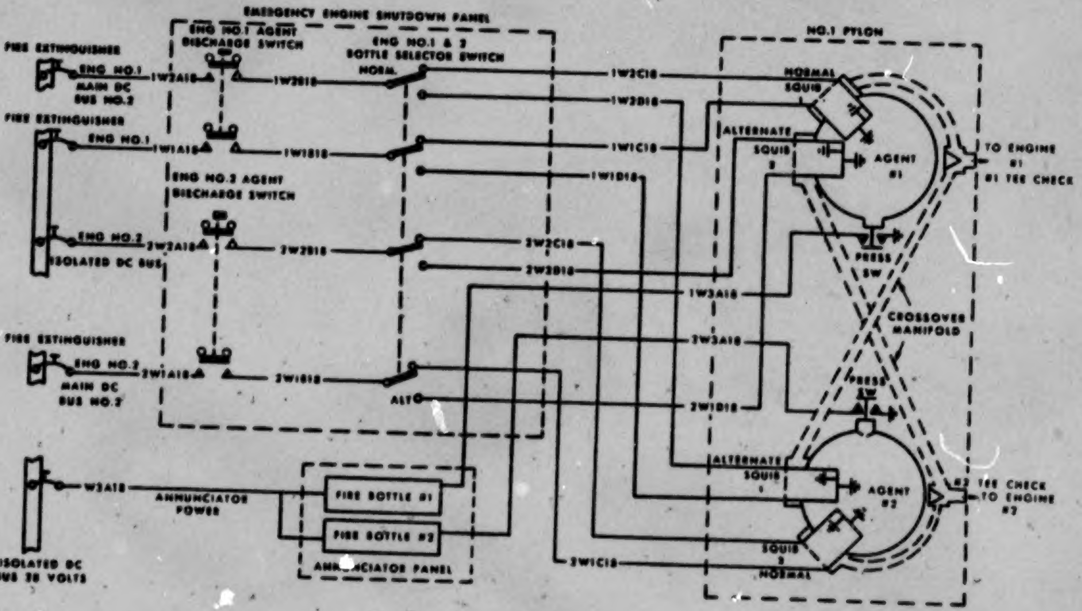
_____4. Only one tee check valve and one pressure switch is used.

3018

Answers to Frame 16: 1. T 2. T 3. T 4. ___

Frame 17

Shown below is the complete system for engines 1 and 2. On the emergency engine shutdown panel, we show ENG NO. 1 and ENG NO. 2 agent discharge switches and ENG NO. 1 and 2 bottle selector switch. Note the bottle selector switch is in NORM position. Assume the fire is in NO. 2 engine and you just pushed the ENG NO. 2 agent discharge switch or button. Now follow power from the ENG NO. 2 isolated bus and main bus over and down to squib 2 in the normal discharge head of the agent #2 bottle. When this squib fires, the agent is routed out to NO. 2 engine. Note that the squib receives power from two different circuits for positive firing. The reason two circuits are provided for the squib is to insure its firing if one of the two circuits were to fail. A back-up circuit is provided for both the normal and the alternate squib in each agent bottle. Locate the pressure switch on each bottle. When pressure drops below 225 psi or when a bottle is discharged, a ground is made which lights the fire bottle #1 or fire bottle #2 light on the annunciator panel (shown). The flight engineer checks the condition of the bottles by these two lights.


EMERGENCY ENGINE SHUTDOWN PANEL
ENG NO.1 AGENT DISCHARGE SWITCH
ENG NO.1 & 2 BOTTLE SELECTOR SWITCH
NORM.
FIRE EXTINGUISHER
ENG NO.1
MAIN DC BUS NO.2
1W2A18
1W2B18
FIRE EXTINGUISHER
ENG NO.1
1W1A18
1W1B18
ENG NO.2 AGENT DISCHARGE SWITCH
ENG NO.2
ISOLATED DC BUS
2W2A18
2W2B18
FIRE EXTINGUISHER
ENG NO.2
MAIN DC BUS NO.2
2W1A18
2W1B18
ALT
W3A18
ANNUNCIATOR POWER
FIRE BOTTLE #1
FIRE BOTTLE #2
ANNUNCIATOR PANEL
ISOLATED DC BUS 28 VOLTS
NO.1 PYLON
1W2C18
1W2D18
1W1C18
1W1D18
2W2C18
2W2D18
1W3A18
2W3A18
2W1D18
2W1C18
NORMAL SQUIB 1
ALTERNATE SQUIB 2
AGENT #1
TO ENGINE #1
#1 TEE CHECK
PRESS SW
CROSSOVER MANIFOLD
PRESS SW
ALTERNATE SQUIB 1
AGENT #2
#2 TEE CHECK
TO ENGINE #2
SQUIB 2 NORMAL

Select the following statement(s) that is/are true.

_____1. With the bottle selector switch in "normal" the normal squibs will fire.

_____2. The alternate discharge head on agent #2 container sends agent to engine NO. 1.

_____3. Each squib has two circuits for positive firing.

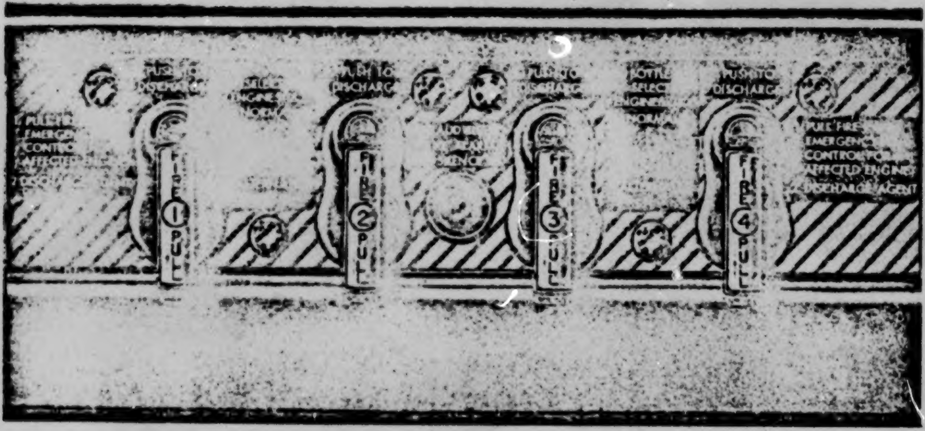
_____4. The pressure switch on each bottle is connected to a light on the annunciator panel.

3019

Answers to Frame 17: 1. T 2. T 3. T 4. T

Frame 18

Now that you are familiar with the fire extinguishing system and components, let's discuss the engine emergency shutdown or isolation system for each engine. On the engine fire emergency control panel shown below we have four fire emergency control handles. Note that each handle is marked for the engine which it controls. When a fire exists, the pilot first positions the bottle selector switch to normal or alternate. He then pulls the fire handle for the effected engine and depresses the agent discharge button behind the handle. When a handle is pulled, it shuts off fuel, bleed air and hydraulic fluid to that engine. Each handle is connected by cable to the fuel shutoff valve for that engine. When the fuel valve is manually closed, contacts are closed to energize two relays which shutdown the other systems.



ENGINE FIRE EMERGENCY CONTROL PANEL

Select the following statement(s) that is/are true.

_____1. When a fire handle is pulled, that particular engine will shut down.

_____2. When the fire handle is pulled, the agent is automatically released.

_____3. The fire handles are cable connected to the engine fuel shutoff valves.

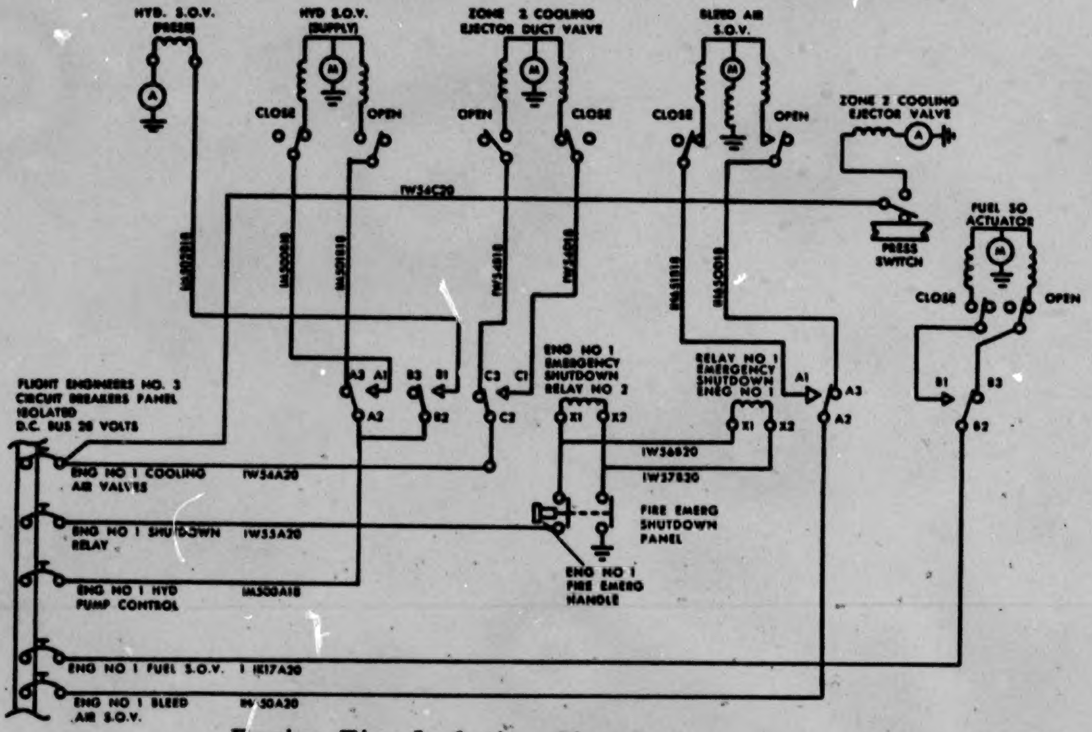
_____4. The agent discharge switch is uncovered when the fire handle is pulled.

_____5. When a fire handle is pulled, fuel, bleed air and hydraulic fluid is shut off.

Answers to Frame 18: 1. T 2. ___ 3. T 4. T 5. T

Frame 19

The #1 engine emergency shutdown circuit is shown below. Notice when the engine #1 fire handle is pulled, emergency shutdown relays NO. 1 and NO. 2 are energized. Relay NO. 1 completes a circuit to close the bleed air shutoff valve and also allows the fuel shutoff actuator to close. Relay NO. 2 completes circuits to close the hydraulic shutoff valves (both pressure and supply) and also closes the zone 2 cooling ejector duct valve. When the zone 2 cooling ejector duct valve closes, the pressure decreases on a pressure switch which completes a circuit to close the zone 2 cooling ejector valve and stops the flow of cooling air. You can now see that hydraulic fluid, bleed air, fuel and cooling air are isolated from the engine to prevent feeding the fire and spreading it to other areas.


HYD. S.O.V. (PRESS)
HYD S.O.V. (SUPPLY)
ZONE 2 COOLING EJECTOR DUCT VALVE
BLEED AIR S.O.V.
CLOSE
OPEN
OPEN
CLOSE
CLOSE
OPEN
ZONE 2 COOLING EJECTOR VALVE
IW54C20
PRESS SWITCH
FUEL SO ACTUATOR
CLOSE
OPEN
A3 A1
B3 B1
C3 C1
A2
B2
C2
ENG NO 1 EMERGENCY SHUTDOWN RELAY NO 2
X1 X2
RELAY NO 1 EMERGENCY SHUTDOWN ENG NO 1
X1 X2
A1
A3
A2
B1
B3
B2
FLIGHT ENGINEERS NO. 3 CIRCUIT BREAKERS PANEL ISOLATED D.C. BUS 28 VOLTS
ENG NO 1 COOLING AIR VALVES
IW54A20
IW36B20
IW37B20
ENG NO 1 SHUTDOWN RELAY
IW55A20
FIRE EMERG SHUTDOWN PANEL
ENG NO 1 FIRE EMERG HANDLE
ENG NO 1 HYD PUMP CONTROL
IM500A18
ENG NO 1 FUEL S.O.V.
1 IK17A20
ENG NO 1 BLEED AIR S.O.V.
IW50A20

Engine Fire Isolation Circuit.

Select the following statement(s) that is/are true.

_____1. The fire isolation system prevents feeding fuel, hydraulic fluid, and cooling air to an engine fire.

_____2. When the hydraulic shutoff valve (pressure) closes, a light illuminates to indicate a loss in pressure.

_____3. The zone 2 cooling ejector duct valve will close before the zone 2 cooling ejector valve does.

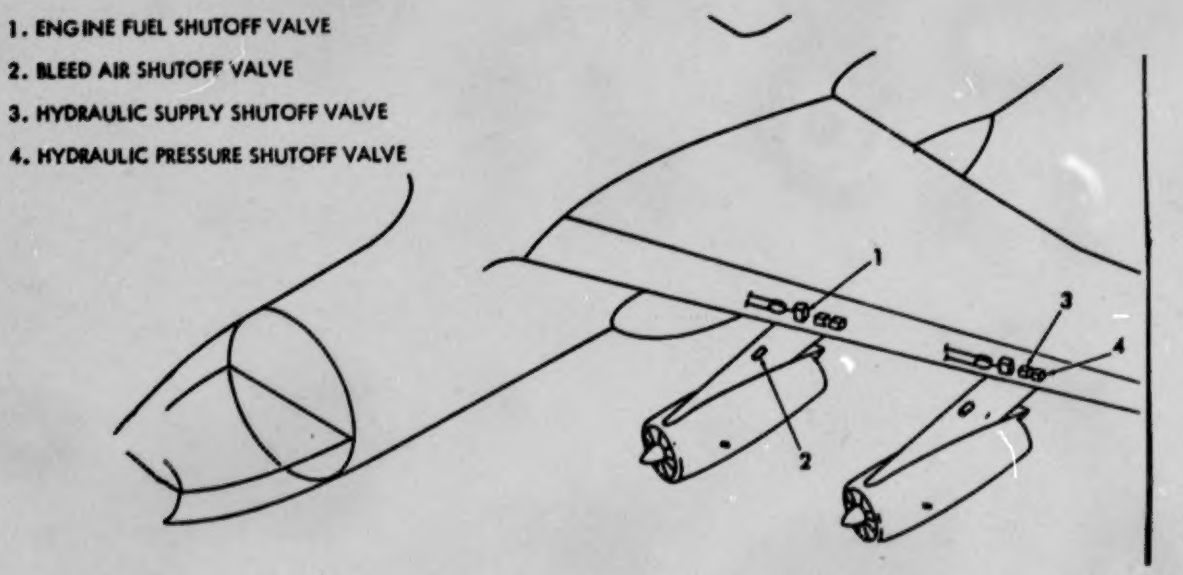
_____4. The fire extinguishing agent is discharged before the pilot pulls the fire emergency handle.

3021

Answers to Frame 19: 1. T 2. T 3. T 4. ___

Frame 20

The engine fire isolation components are located as shown below for engines 1 and 2. Keep in mind we have the same fire extinguishing and isolation components for engines 3 and 4.


1. ENGINE FUEL SHUTOFF VALVE
2. BLEED AIR SHUTOFF VALVE
3. HYDRAULIC SUPPLY SHUTOFF VALVE
4. HYDRAULIC PRESSURE SHUTOFF VALVE
1
2
3
4

Engine Fire Isolation Components for Engines 1 and 2.

Circle the correct answer to the following questions.

1. The agent used in the fire extinguishing system shown above is

   a. AB.
   b. MB.
   c. DB.
   d. CB.

2. In order to discharge the agent to an engine, the pilot must first

   a. select the bottle to be used and pull all four fire handles.
   b. select the bottle to be used and pull the fire handle for that engine.
   c. dump all the aircraft fuel overboard.
   d. pull all four handles to see if the fire goes out.

Answers to Frame 20: 1. c 2. b

Frame 21

Let's discuss some of the hazards and safety precautions that apply to working with and handling liquid fire extinguishing agents. We will discuss CB as the common agent but the same conditions apply to DB and BT or any other liquid agent. CB is a volatile (evaporates rapidly) liquid, and its vapors are toxic. It should be used with adequate ventilation whenever possible. Avoid exposure to high concentrations of CB for staggering, dizziness, lack of coordination, stupor, confusion, headache, nausea, or unconsciousness may result. If overexposure is noted, leave the area at once. If this is impossible, use an oxygen or air supplying mask. After overexposure, report to first aid immediately. Personnel regularly exposed to CB will be given a medical examination at intervals set up by the base hospital.

Select the following statement(s) that is/are true.

_____1. CB produces a vapor that is toxic.

_____2. Overexposure to CB vapors can cause unconsciousness.

_____3. If you notice the symptoms of overexposure, you should report to first aid immediately.

_____4. Personnel who handle CB and are regularly exposed to the vapors will have a periodic medical examination.

_____5. CB should be used in a well ventilated area.

3023

Answers to Frame 21: 1. T 2. T 3. T 4. T 5. T

Frame 22

A full face type shield will be worn when handling liquid agents, recharging or weight checking containers. Neoprene gloves and aprons will also be worn. A skin rash may result from prolonged or repeated contact with CB. If CB is spilled on the skin, it must be washed off with soap and water. Contaminated clothing must be removed immediately and thoroughly dried prior to reuse. Clean water must always be available in a CB area for washing the eyes. Although liquid agents are irritating to the eyes, no permanent injury will result if the eyes are thoroughly washed out immediately following the accident.

Select the following statement(s) that is/are true.

_____1. An eye shield, neoprene gloves and apron will be worn when recharging liquid agent containers.

_____2. CB will be washed off the skin with soap and water.

_____3. If CB gets into the eyes, they will be flushed out with clean water.

_____4. If CB is spilled on your clothing, the clothing will be removed immediately.

_____5. A skin rash will result from prolonged or repeated contact with CB.

_____6. Clean water will always be available in a CB area.

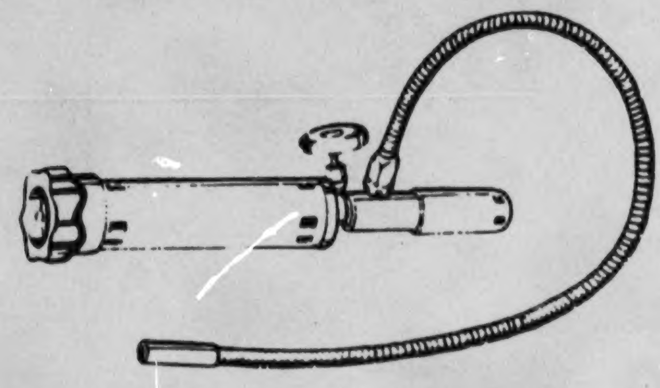
_____7. No special clothing is required when handling liquid agents.

_____8. No permanent damage will result if CB is washed out of the eyes immediately.

Answers to Frame 22: 1. T 2. T 3. T 4. T
5. T 6. T 7. ___ 8. T

Frame 23

Besides producing toxic vapors, CB is also dangerous in another respect. Since it is designed to exclude oxygen from a fire, it will exclude the oxygen from any enclosed area. This is the reason for having a well ventilated room when handling CB. If your CB work area becomes contaminated with a high concentration of CB, a "Bale Test" will be performed before reentering the area. This test is performed by the base medical office. For leak testing a fully charged CB container, a "Halide" leak detector is used. This detector is a torch affair that burns alcohol and produces a blue flame. When the detector tube is passed over a leak on a CB container, the flame turns green.



Halide Leak Detector Torch.

Select the following statement(s) that is/are true.

_____1. CB will be used in a well ventilated area.

_____2. A Bale Test will be performed in an area contaminated with CB.

_____3. A high concentration of CB will remove the oxygen from an enclosed area.

_____4. A Halide leak detector is used to leak check a fully charged CB container.

_____5. A green flame from a Halide leak detector indicates a CB leak.

_____6. A high concentration of CB vapors in an enclosed area will not harm you.

_____7. The Halide leak detector is a torch that produces a blue flame.

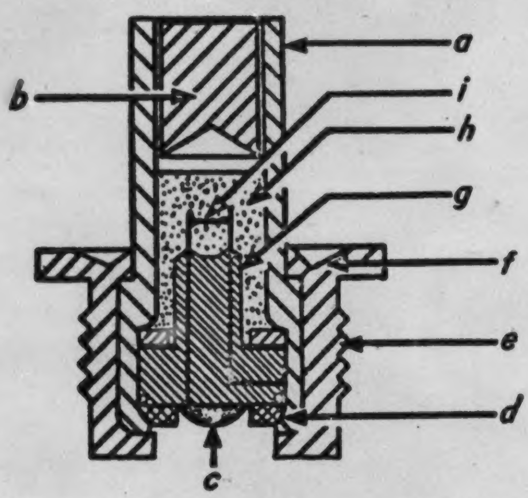
3025

Answers to Frame 23: 1. T 2. T 3. T 4. T
5. ___ 6. T

Frame 24

Another safety hazard you will come in contact with is the cartridge or squib used to release the agent from the container or bottle. Never attempt to check cartridge continuity unless the cartridge is properly installed in the discharge bonnet. Be sure the bonnet is secure on the bottle, and the bottle is bolted to the installation brackets.

When checking cartridge continuity, use an ohmmeter which produces a currrent of 35 milliamperes or less. A larger current might detonate the cartridge. In other words, a PSM-37 multimeter might fire the cartridge. A cartridge or squib is a highly sensitive device.



a. Cartridge
b. Slug
c. Positive terminal
d. Washer
e. Nut
f. Crimped shoulder
g. Ground terminal
h. Gun cotton (explosive)
i. Fuse wire

Cartridge Assembly.

Select the following statement(s) that is/are true.

_____1. Not more than 35 milliamperes should be applied to the cartridge.

_____2. A PSM-37 is used to check cartridge continuity.

_____3. The cartridge or squib must be in the bonnet when checking continuity.

_____4. The cartridge is a highly sensitive device.

Answers to Frame 24: 1. T 2. ___ 3. T 4. T

3026
PROGRAMMED TEXT

3ABR42331-PT-406A

Technical Training

Aircraft Environmental Systems Mechanic

AIRCRAFT FIRE EXTINGUISHING SYSTEM RECHARGING EQUIPMENT

14 November 1978

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.

Do Not Use on the Job.

ATC FORM 214 (JAN 76) OBSOLETES ATC FORMS 214, MAY 69, 522, NOV 63 AND 523, MAY 71. STANDARD COVERSHEET

3027

FOREWORD

This programmed text was developed for use in the 3ABR42331 instructional system. The material contained herein was validated with 30 students from the subject course. Over 90% of the students achieved the objectives as stated. Average time for completion of the text was 17 minutes.

OBJECTIVES

After completion of this programmed text, you will be able to:

1. Relate four (4) out of five (5) components of the fire extinguishing servicing unit to their purpose.

2. Select safety precautions, without error, involved in handling five extinguishing agents.

INSTRUCTIONS

This programmed text presents information in small steps called "frames." After each frame you will be required to respond to questions or statements as directed. Read the information presented and make your response before you check the correct answer. If your answer does not agree, go over the material until you understand your error before proceeding to the next frame. When you have finished the programmed text, the instructor will give you the criterion test.

Supersedes 3ABR42231-PT-306, 3 November 1970; 3ABR42331-PT-407, 29 August 1977.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 600; TTVSA - 1

In previous lessons we discussed aircraft liquid agent bottles or containers. We said that the bottles or cylinders are filled by weight and contain pressure. We also mentioned that dry nitrogen (N_2) is added to the agent to assist in expelling it from the container of low temperatures.

At various intervals as prescribed by aircraft inspection TOs, these bottles or cylinders are removed from the aircraft and a weight check is performed. If recharging is required, this task will most likely fall on the Environmental Systems Shop.

In this text we will discuss the equipment used to recharge liquid agent containers.

Select the following statement(s) that is/are true.

_____1. Aircraft fire bottles are filled by weight.

_____2. Dry nitrogen is added to all aircraft fire bottles.

_____3. A weight check is performed with the bottle installed in the aircraft.

_____4. Your shop may be responsible for recharging aircraft fire bottles.

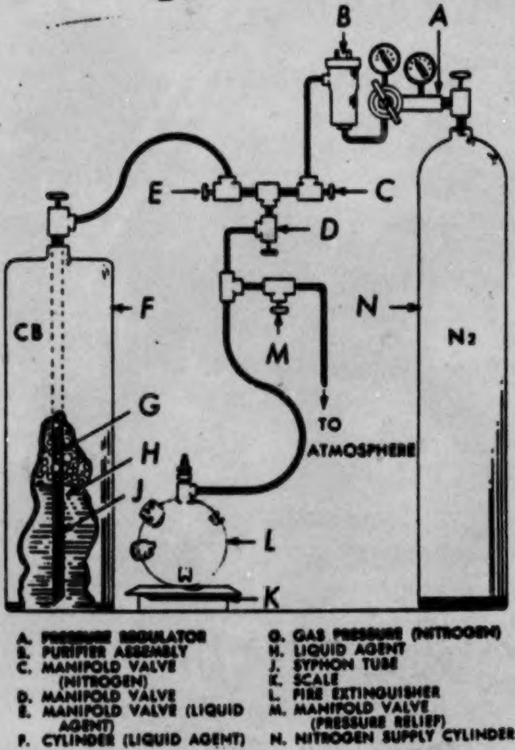
3029

Answers to Frame 1: 1. T 2. T 3. ___ 4. T

Frame 2

Shown below is a typical recharge setup for recharging aircraft CB spheres. The two agents most widely used are chlorobromomethane (CB) and dibromodifluoromethane (DB). Note in the illustration that the CB storage cylinder (F), has a syphon tube (J) and stands with the valve end up. The CB storage cylinder is pressurized with nitrogen (G) which pushes the CB out the syphon tube (J) and into the sphere (L).

On the other side of the setup, we have the nitrogen supply cylinder (N). Nitrogen is drawn from the supply cylinder, through the pressure regulator (A) and through the purifier unit (B) to the aircraft sphere (L) which is mounted on the scales (K). The purifier assembly is not a mandatory item on the liquid agent setup.


B
A
E
C
D
F
N
CB
N₂
M
G
H
J
TO ATMOSPHERE
L
K
W
A. PRESSURE REGULATOR
B. PURIFIER ASSEMBLY
C. MANIFOLD VALVE (NITROGEN)
D. MANIFOLD VALVE
E. MANIFOLD VALVE (LIQUID AGENT)
F. CYLINDER (LIQUID AGENT)
G. GAS PRESSURE (NITROGEN)
H. LIQUID AGENT
J. SYPHON TUBE
K. SCALE
L. FIRE EXTINGUISHER
M. MANIFOLD VALVE (PRESSURE RELIEF)
N. NITROGEN SUPPLY CYLINDER

CB (Chlorobromomethane Recharge Setup.

Select the following statement(s) that is/are true.

_____1. CB and DB are the most common liquid agents used.

_____2. The purifier assembly is not mandatory in the CB setup.

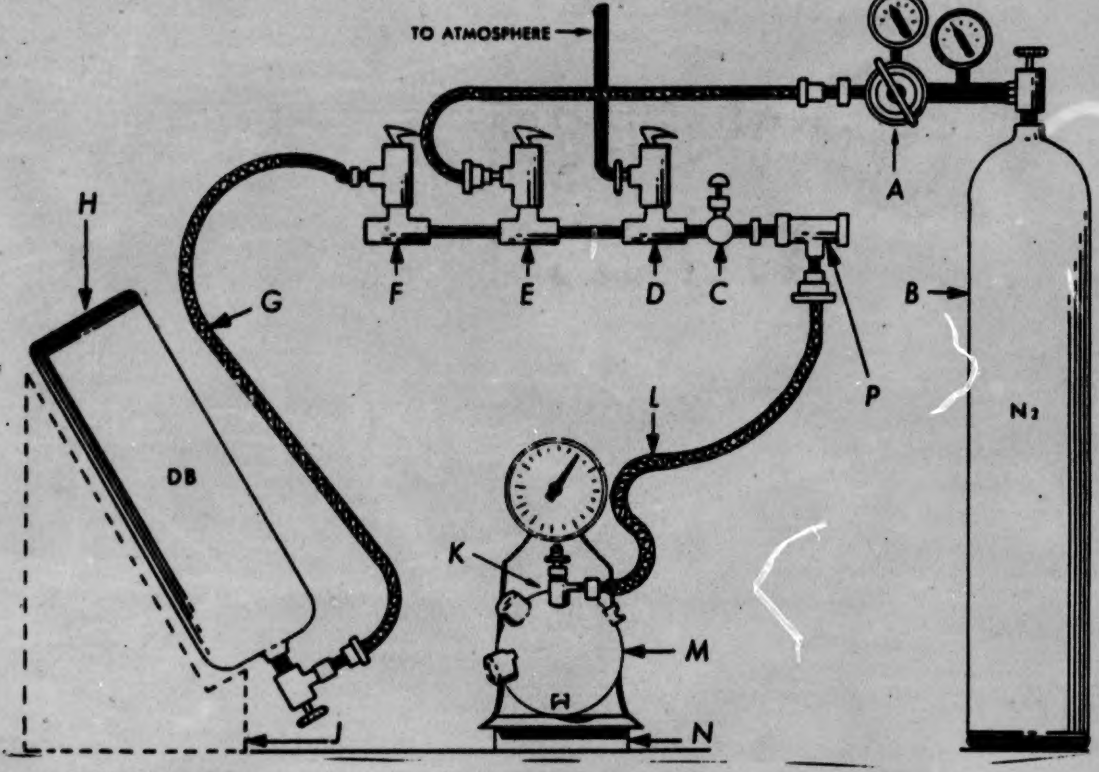
_____3. The fire bottle is mounted on the scales during recharging.

Answers to Frame 2: 1. T 2. T 3. T

Frame 3

Shown below is the recharging setup for dibromodifluoromethane (DB). Note the only new component in this setup is the filter (P) which is the last unit in the manifold before the liquid agent reaches the fire bottle. Also note the DB cylinder is inverted.

In a fire extinguisher shop you will find only one liquid agent recharge setup. This one setup is used for all liquid agent recharging. The only requirement in doing this is that the setup must be purged with compressed air when changing from one agent to another.



A. PRESSURE REGULATOR
B. NITROGEN SUPPLY CYLINDER
C. LINE VALVE
D. LINE VALVE (PRESSURE RELIEF)
E. LINE VALVE (NITROGEN SUPPLY)
F. LINE VALVE (CF_2Br_2 SUPPLY CYLINDER)
G. CF_2Br_2 SUPPLY LINE
H. CF_2Br_2 SUPPLY CYLINDER
J. STAND
K. CHARGING BONNET
L. CHARGING LINE
M. EXTINGUISHER
N. SCALE
P. FILTER

DB (CF_2Br_2) Recharge Setup.

Select the following statement(s) that is/are true.

_____1. The only difference in the CB and DB setup is the agent.

_____2. One liquid agent recharge setup can be used to recharge all liquid agents.

_____3. When changing from one agent to another, the recharge setup must be completely purged.

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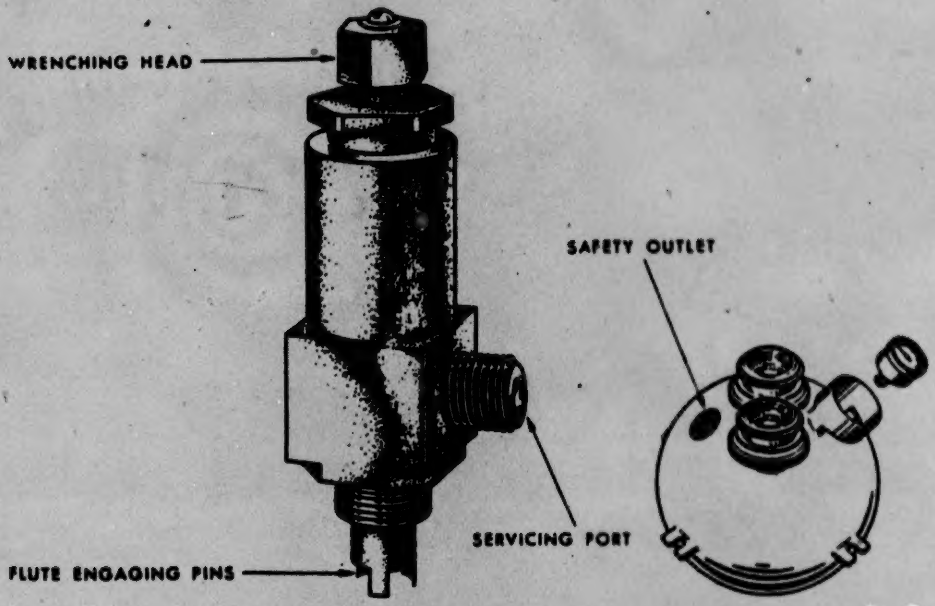
Answers to Frame 3: 1. ___ 2. T 3. T

Frame 4

One type of liquid agent container charging bonnet (adapter) is illustrated below. The charging bonnet is screwed into the thermal relief port or safety outlet (note fire bottle below). The bonnet unseats the thermal relief device without actually removing it from the container. Note the bonnet has a wrenching head at the top and flute engaging pins on the bottom. These pins engage the flutes in the thermal relief device (safety plug) and the wrenching head is turned to back off the safety plug and the agent enters the container. The charging line is connected to the servicing port.



Liquid Agent Charging Bonnet.

Select the following statement(s) that is/are true.

_____1. Liquid containers are filled through the thermal relief or safety outlet.

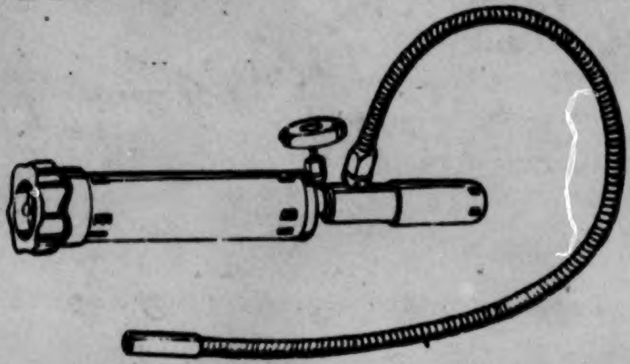
_____2. When the charging bonnet is installed, the wrenching head is turned to unseat the safety plug.

Answers to Frame 4: 1. T 2. T

Frame 5

Once you have recharged a CB or DB container, it must be leak tested before being reinstalled on the aircraft. Special attention should be given to the thermal relief device (safety plug) when leak testing, as this is where a leak is most likely to occur. In general, you can make leak tests by timing pressure drops (pressure gage on container), soap and water bubble tests, or with a halide leak detector (shown below). The 13F series technical orders will give specific leak tests to be performed on a particular container.

The halide leak detector burns methyl alcohol and the flame will change color when the open end of its flexible sniffer tube is held close to a liquid agent container that has a leak. The normal flame is blue; a small leak produces a green flame, and a large leak changes the color to a bright blue.



Halide Leak Detector Torch.

Select the following statement(s) that is/are true.

_____1. A leak is most likely to occur around the safety plug.

_____2. A leak test can be made by timing the pressure drop.

_____3. The halide leak detector burns methyl alcohol.

_____4. When burning, the normal color of the alcohol flame is red.

_____5. When a leak is detected, the halide flame will turn green or a bright blue.

Answers to Frame 5: 1. T 2. T 3. T 4. ___ 5. T

Frame 6

When handling liquid agents, such as recharging or weight checking containers, a full face type eye shield should be worn. Neoprene gloves and apron should also be worn when considered practicable. A skin rash may result from prolonged or repeated contact with CB. If CB is spilled on the skin, it should be washed off with soap and water. Contaminated clothing should be removed immediately and thoroughly dried prior to reuse. Clean water should always be available in a CB area for washing the eyes. Although CB is irritating to the eyes, no permanent injury should result if the eyes are thoroughly washed out immediately following the accident.

Select the following statement(s) that is/are true.

____1. An eye shield, neoprene gloves and apron should be worn when recharging a CB container.

____2. CB should be washed off the skin with soap and water.

____3. If CB gets into the eyes, they should be flushed out with clean water.

____4. If CB is spilled on your clothing, they should be removed immediately.

____5. A skin rash may result from prolonged or repeated contact with CB.

____6. Clean water should always be available in a CB area.

____7. No special clothing is required when handling CB.

____8. No permanent damage should result if CB is washed out of the eyes immediately.

Answers to Frame 6: 1. T 2. T 3. T 4. T
5. T 6. T 7. ___ 8. T

Environmental Pneudraulic Branch
Chanute AFB, Illinois

3ABR42331-WB-406
6 July 1978

INSPECTION AND OPERATIONAL CHECK OF A FIRE EXTINGUISHING SYSTEM

OBJECTIVES

1. Using a fire extinguishing trainer, inspection workcard and maintenance data collection forms, inspect the fire extinguishing system, recording a minimum of five (5) discrepancies on appropriate forms. One instructor assist per form is permissible.

2. Using a trainer, do an operational check of the fire extinguishing system, with one instructor assist.

EQUIPMENT

	Basis of Issue
Fire Extinguishing System Trainer 3180	1/4 students

Note: The last page of this text contains an illustration of the fire extinguishing trainer number 3180. This illustration can be used to locate any part not identified on the actual trainer. Compare it to the trainer as you read through the procedures the first time.

INSPECTION PROCEDURES

1. Have the instructor set up fire extinguishing film number AVA C-141.

2. Using the AFTO Form 26, provided by your instructor as a guide, inspect each item listed, record a minimum of 5 discrepancies on the AFTO Form 349. One instructor assist per form is permissible.

OPERATING PROCEDURES

Any trainer malfunction should be brought to the instructor's attention.

1. Remove all jewelry before operating this equipment.

2. Inspect the fire extinguishing trainer for the following:

   a. All circuit breakers are pushed in.

   b. All fire handles are pushed in.

   c. Bottle selector switch for engines 1 and 2 in NORM (normal).

   d. All trouble switches in the out position (located on back of trainer).

Supersedes 3ABR42231-WB-406, 4 August 1975.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 600; TTVSA - 1

Designed for ATC Course Use. Do Not Use on the Job.

3035

3. Connect the trainer to 28V DC. The power cord is coiled up behind the trainer. 28V DC outlets are on the wall.

4. Place the trainer power master switch "ON." This switch is located directly below the box containing the trouble switches.

5. Now visually check the following:

a. Squib firing lights (RED) should be "OFF."

b. Annunciator panel lights (RED) for fire bottles Number 1 and Number 2 should be "OFF."

c. The HYD shutoff valve (hydraulic) should be "OPEN" (amber indicating light "OFF").

d. The HYD supply shutoff valve should be "OPEN."

e. The ejector valve should be "OPEN" (amber indicating light "ON"). The pressure switch holds the ejector valve open.

f. The bleed air shutoff valve should be "OPEN."

g. The manual fuel shutoff valve should be "OPEN." On the trainer this valve is connected by cable to the Number 1 (only) engine emergency fire handle. In the aircraft each fire handle is connected by cable to a manual fuel valve for that engine.

h. The ejector duct valve actuator (cooling air) should be "OPEN" or extended. This actuator will open or close a small door on the engine cowling for cooling purposes.

i. The fuel shutoff valve actuator should be extended (valve not shown on trainer).

j. Only the two way check valves are shown since tubing is not used on the trainer. Normally these two check valves are in the manifold tubing connecting the two fire bottles. The spring loaded "flappers" in the check valves position in response to the direction of agent flow.

k. The wiring for the system is routed through the two mergency shutdown relays on the lower right corner of the trainer.

6. To energize the engine emergency shutdown system, "pull" the ngine Number 1 fire handle.

a. Check that all valves "close."

b. Ejector valve amber light should go "off" (indicator valve osed and pressure dropped).

c. HYD shutoff valve amber light should come "ON" (indicating lve has closed).

d. We now have fuel, hydraulic fluid, bleed air, and cooling air shut off from the Number 1 engine.

7. To energize the fire extinguishing system, press the "push to discharge" button which was uncovered when Number 1 handle was pulled.

a. With the bottle selector switch in "NORM," the circuit will fire the "NORM" squib in fire bottle Number 1 (check the red squib firing lights).

b. The fire bottle Number 1 red light on the annunciator panel should come "ON" (these two lights are connected to the pressure switch in the fire bottles; a pressure drop to 225 psi or below will turn on these lights.) The pilot now knows that the agent in fire bottle Number 1 has been sent to engine Number 1.

8. If for some reason one bottle did not extinguish the fire in engine Number 1, the bottle selector switch would be positioned to "ALT" (flip this switch down). Now press the "press to discharge" button for engine Number 1 again.

a. The circuit will now fire the "alternate" squib in fire bottle Number 2 (check squib firing lights). The agent in this bottle will also go to engine Number 1.

b. The fire bottle Number 2 red light on the annunciator panel should come "ON." (Drop in pressure to 225 psi or lower turns on this light.)

c. If this firing sequence is not clear, use the wiring diagram on the trainer and trace the circuit out with a grease pencil. (Wiring diagrams are in the upper right hand corner of the trainer.)

9. To reset the trainer for another operation:

a. Place the bottle selector switch back to "NORM."

b. Push fire handle Number 1 back in.

c. Check that all valves return to the "OPEN" position.

d. The ejector valve amber light should be "ON" and the HYD shutoff valve amber light "OFF."

e. Place the trainer power master switch "OFF" and then "ON" again to reset the squib firing and annunciator panel lights. (On the aircraft these bottles must be recharged to turn "OFF" the annunciator lights.)

10. For this check, assume the fire is in the Number 2 engine.

a. Pull the fire handle for engine Number 2. Check that all valves close.

b. Press the "push to discharge" button behind the Number 2 handle.

c. With the bottle selector switch in "NORM," the circuit will now fire the "NORM" squib in fire bottle Number 2. (Check squib firing lights.)

d. The fire bottle Number 2 light on the annunciator panel should come "ON."

11. If this did not extinguish the fire, bottle Number 1 can be used.

a. Position the bottle selector switch to "ALT."

b. Press the "push to discharge" button again.

c. The circuit will now fire the "alternate" squib in fire bottle Number 1 and send the agent to engine Number 2. (Check the squib firing lights.)

d. The fire bottle Number 1 light on the annunciator panel will now come "ON."

e. Check the wiring diagram on the trainer to see how this happens.

12. Shut the trainer down as follows:

a. Push engine Number 2 fire handle in.

b. Position the bottle selector switch back to "NORM."

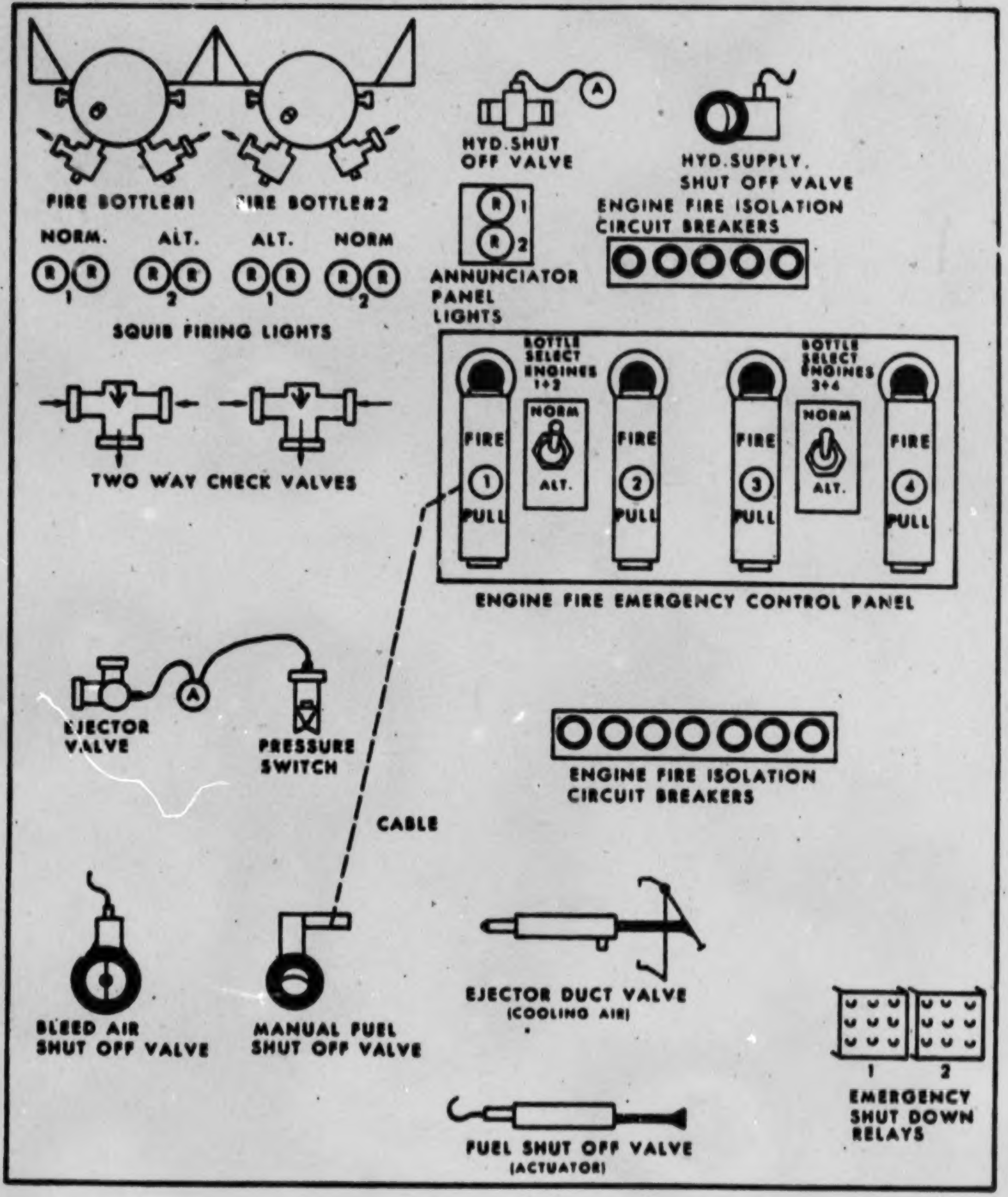
c. Place the trainer power master switch "OFF."

d. Remove the trainer power cord from the 28V DC outlet and position it behind the trainer.

13. Additional Information:

a. The complete operational checkout sequence for the fire extinguishing system is outlined in 1C-141A-2-7. Normally, the connector plugs are removed from the squibs and a test set is used to check the electrical circuit.

b. The only indicating lights found on the aircraft fire extinguishing system are the fire bottle lights on the annunciator panel. The squib firing and valve operation lights are on the trainer only. This completes the operational chekk of the fire extinguishing system. Chekk with your instructor before continuing.


FIRE BOTTLE#1
FIRE BOTTLE#2
NORM.
ALT.
ALT.
NORM
R
1
2
SQUIB FIRING LIGHTS
HYD. SHUT OFF VALVE
A
HYD. SUPPLY. SHUT OFF VALVE
ANNUNCIATOR PANEL LIGHTS
ENGINE FIRE ISOLATION CIRCUIT BREAKERS
TWO WAY CHECK VALVES
BOTTLE SELECT ENGINES 1+2
BOTTLE SELECT ENGINES 3+4
NORM
ALT.
FIRE
PULL
1
2
3
4
ENGINE FIRE EMERGENCY CONTROL PANEL
EJECTOR VALVE
PRESSURE SWITCH
ENGINE FIRE ISOLATION CIRCUIT BREAKERS
CABLE
BLEED AIR SHUT OFF VALVE
MANUAL FUEL SHUT OFF VALVE
EJECTOR DUCT VALVE (COOLING AIR)
FUEL SHUT OFF VALVE (ACTUATOR)
EMERGENCY SHUT DOWN RELAYS

Engine Fire Isolation and Extinguishing System Trainer.

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3039

Environmental Pneudraulics Branch
Chanute AFB, Illinois

3ABR42331-WB-406A
14 July 1978

TROUBLESHOOTING FIRE EXTINGUISHING AND ENGINE ISOLATION SYSTEMS

OBJECTIVES

After completing this workbook, you will be able to:

1. Use a fire extinguishing trainer and multimeter to troubleshoot the system for malfunctions, locating four (4) of six (6) causes correctly.

EQUIPMENT

	Basis of Issue
Trainer number 3180	1/4 students
Multimeter	1/2 students

INFORMATION

By now you should have inspected and operated the fire extinguishing trainer. You should have a good idea of how the system operates. In this project, you will troubleshoot the system by locating defects that are put in the system by trouble switches. These defects will be open or shorted wires. Troubles are not placed in the units. Note that test jacks have been put in each circuit on the trainer. With test jacks there is no need to take off the AN connector plugs to check a circuit.

When you check the various circuits, use a grease pencil to trace the circuit on the plastic covered wiring diagram. The diagram is on the trainer. This will keep you from checking the same circuit twice.

Supersedes 3ABR42331-WB-406A, 3 September 1975.
OPR: 3370 TCHTC
DISTRIBUTION: X
3370TCHTG/TTGU-P - 500; TTVSA - 1

Designed for ATC Course Use. Do Not Use on the Job.

3040

PROCEDURES

1. Set up the trainer for normal operation (power switch ON and master switch ON).

2. Find trouble switch number 3. The trouble switches are on the right side of the trainer.

3. Place this trouble switch to the IN position.

4. Look at Table 1 and read the discrepancy

Trouble Switch	Discrepancy
3	The squib firing light for circuit "A" does not come ON, when the bottle selector switch is in "NORM" and engine #1 discharge button is pushed.
4	Alternate circuit "A" engine #1 will not fire.
7	No response from the electrical circuit when engine #1 fire handle is pulled.
8	The hydraulic supply shutoff valve will not OPEN when engine #1 fire handle is pushed.
9	The ejector duct valve will not CLOSE when engine #1 fire handle is pulled.
11	The bleed air shutoff valve will not CLOSE when the engine #1 handle is pulled. The shutoff valve will not OPEN when the engine #1 handle is pushed.

Table 1. Troubleshooting.

> WARNING: When a fire extinguishing system needs maintenance, be sure that the AN connector plugs are off the firing squibs before a multimeter is used. The battery in the meter has the current that would fire a squib. When a squib needs to be checked, use a meter than CANNOT give more than 35 milliamperes of current. This type of meter will be taught in the next text. Be sure to check the technical order for the aircraft on which you are working.

5. Pull the number 1 fire handle.

6. Press the push to discharge button (located under the fire handle) for the number 1 engine.

7. Watch the squib firing lights.

8. Since the circuit "A" squib firing light DID NOT come ON, check the trainer wiring diagram for test points.

9. Check the circuit with the multimeter.

NOTE: You can troubleshoot the trainer with power ON or OFF. Make sure you have the meter set correctly when making either a power ON or a power OFF check.

10. After the circuit is checked, you should have found that wire number 1W2B18 was OPEN. This wire is between the number 1 engine discharge button and the bottle selector switch.

11. Mark the wiring diagram to show the problem. Use an "X" and the trouble switch number.

12. Place trouble switch number 3 to the OUT position.

13. Work the next five (5) problems listed in Table 1 by following steps 1 through 12.

14. Have the instructor check your answers before you start the next project.

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Environmental Pneudraulics Branch
Chanute AFB, Illinois

3ABR42331-WB-406B
14 July 1978

BENCH CHECK FIRE EXTINGUISHING COMPONENTS

OBJECTIVES

After completing this workbook, you will be able to:

1. Using squibs container provided and igniter circuit tester, bench check two (2) squibs for proper resistance value, while observing all safety precautions pertaining to explosive squibs. One (1) instructor assist permissible.

EQUIPMENT

	Basis of Issue
Igniter Cirucit Tester, Type 101-5BF	1/student
Agent Container	1/student
Squib	1/student

INFORMATION

In this project, you will bench check a fire extinguishing bottle squib to find out if it is good. Use the figure on the last page of this book when making this check. The diagram will help you to find some of the components that are not labeled on the tester. Read all of the steps one time, then start the test.

Caution: The squib must always be placed in the agent container when a continuity check is made. If the meter should detonate the squib, the container would discharge the liquid agent.

PROCEDURE

1. Check the condition of the squib tester before you use it.

a. First, be sure that the SHORTING BAR is put between the binding posts, located at the top of the tester.

Caution: Never press the OPERATING KEY when the shorting bar is not in place, or when the SPRING CLIP LEADS are not hooked to the squib. This could damage parts in the tester.

Supersedes 3ABR42231-WB-406B, 10 September 1975.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370TCHTG/TTGU-P - 600; TTVSA - 1
Designed for ATC Course Use. Do Not Use on the Job.

b. Set the OHMS DIGITAL DIAL to read all zeros by turning the DIGITAL DIAL KNOB counterclockwise (CCW).

c. Set the OHMS ADD SELECTOR SWITCH to zero.

d. Press the operating key and watch the pointer on the meter. If the pointer does not move, the tester circuit is good. If the pointer moves, there is an open in the tester circuit. Check with your instructor if the pointer moves.

2. Using the Squib tester.

a. Remove the shorting bar from between the two binding posts.

b. The resistance value will vary with different squibs. The resistance value and tolerance of the squibs you will test are 2.30 ± 0.50 ohms. Set a resistance value of 2.30 ohms in the ohms digital dial by turning the digital dial knob clockwise (CW).

c. Hook the spring clip leads to the AN connector plug located on the top of the tester.

d. Hook a spring clip lead to one of the pins of the AN connector on the squib under test. Hook the other lead to the ground terminal of the squib.

Note: Since you will check both the A and B circuits in each squib, it is not too important whether A or B is checked first.

e. Press the operating key and watch the meter pointer. If the pointer moves, increase or decrease the ohms value you had set in the ohms digital dial. Keep adjusting until the meter pointer is centered on the red line of the meter scale.

f. With the operating key pressed, read the ohms digital dial. The reading should be 2.30 ± 0.50 ohms. If this is the reading, the squib is good. If the reading is not in tolerance, the squib is bad.

g. If the circuit proves to be good, remove the spring clip lead from the pin and connect it to the other pin to check that circuit.

h. Do steps d, e and f.

i. Let the instructor know the condition of the squib you are testing (good or bad).

EXAMPLE

Your instructor gave you a squib that has a resistance value and tolerance of 2.30 ± 0.50 ohms. Hook one lead to a pin of the squib and the other lead to the ground connection. Set the ohms add selector switch to zero (0). Then, set 2.30 ± 0.50 ohms in the digital dial and press the operating key. If you can center the meter pointer (red line) by adding or subtracting not more than 0.50 ohms, the squib is good. Do the above steps with the other circuit.

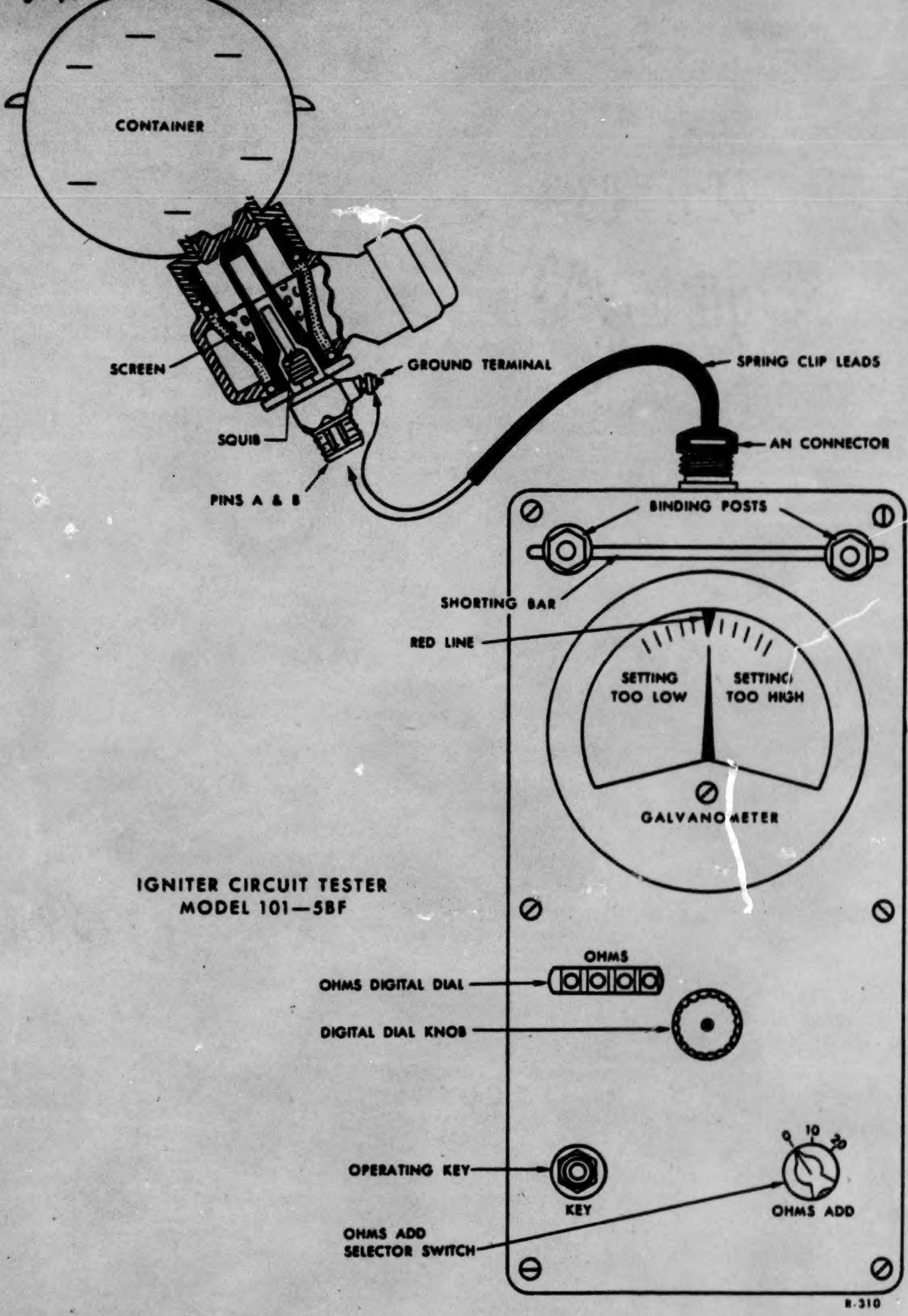
> Note: The ohms add selector switch settings are in ten ohm increments. If the squib resistance is between 0 and 10 ohms, use the zero (0) setting of the switch. If the resistance is betveen 10 and 20 ohms, set the switch on 10. If the resistance is over 20 ohms, set the switch on 20.

3. Securing the squib tester.

Remove the test leads from the squib and tester and store them in the top of the tester cover. Replace the shorting bar between the binding posts and set the OHMS DIGITAL DIAL to read all zeroes.

4. Squib disposal. If the test shows the squib to be bad, the squib must be removed and replaced. The old squib is not thrown into a trash can. Every Air Force base has explosive material disposal procedures that must be followed.

3045


CONTAINER
SCREEN
SQUIB
PINS A & B
GROUND TERMINAL
SPRING CLIP LEADS
AN CONNECTOR
BINDING POSTS
SHORTING BAR
RED LINE
SETTING TOO LOW
SETTING TOO HIGH
GALVANOMETER
OHMS
OHMS DIGITAL DIAL
DIGITAL DIAL KNOB
OPERATING KEY
KEY
0
10
20
OHMS ADD
OHMS ADD SELECTOR SWITCH
R-310

IGNITER CIRCUIT TESTER
MODEL 101—5BF

70-08813

3046

PROGRAMMED TEXT

3ABR42331-PT-407

Technical Training

Aircraft Environmental Systems Mechanic

LIQUID COOLANT SYSTEMS

21 October 1977

3350 TECHNICAL TRAINING WING
3370 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.

Do Not Use on the Job.

3047

FOREWORD

This programmed text was prepared for use in the 3ABR42331 Aircraft Environmental Systems Mechanic Course. The materials contained herein were validated with students from the subject course. At least 90% of the students taking this text achieved or surpassed the criteria established in the lesson objective. The average time for completion of this text was 2 hours.

OBJECTIVES

Relate eight (8) of ten (10) components of a liquid coolant system to its operation.

INSTRUCTIONS

This programmed text presents material in small steps called "frames." After each frame you are asked to select the statement(s) that are true, match items, or complete statements. Read the material in each frame before making your response. The answers to each frame can be found at the top of the next page. If you select the correct answers, continue to the next frame. If you are wrong or in doubt, read the material again and correct yourself before continuing.

OPR: 3370 TTG
DISTRIBUTION: X
3370 TTGTC - 250; TTVSR - 1

433

Frame 1

In older aircraft, radar cooling was accomplished by a fan mounted to the radar unit. When the unit was operating the fan would blow air across it. This was found to be a very poor way to cool a unit that cost as much as the radar unit does. The pilot could not tell if the fan was running or not. A lot of radar units failed because the fan was not operating and the pilot continued to operate the radar unit. In the new aircraft a new type of cooling system has been made for the radar unit. It is called the Liquid Coolant System. We will refer to this as the LCS throughout this PT. The LCS cycles a liquid fluid through the radar unit. As the fluid flows through the radar unit it picks up heat. The fluid then flows through a heat exchanger where the heat is removed by cold air flowing across the fluid. After the heat exchanger the fluid is routed back to the radar unit and continues to cycle in this manner. The LCS operates any time the radar unit is operating. Now we know what the LCS is used for, let us take a look at the components and operation of the system.

Refer to figure A and locate each of the components listed below. Place the circled number of the unit in the blank space alongside the unit name.

a. _____ Low pressure switch

b. _____ Filter

c. _____ Bleed/overboard expansion relief valve

d. _____ Pump

e. _____ Solenoid shutoff valve

f. _____ Modulating valve

g. _____ Delta system bypass valve

h. _____ Reservoir

i. _____ Thermal pilot valve

j. _____ Temperature sensor

k. _____ Heat exchanger

3049

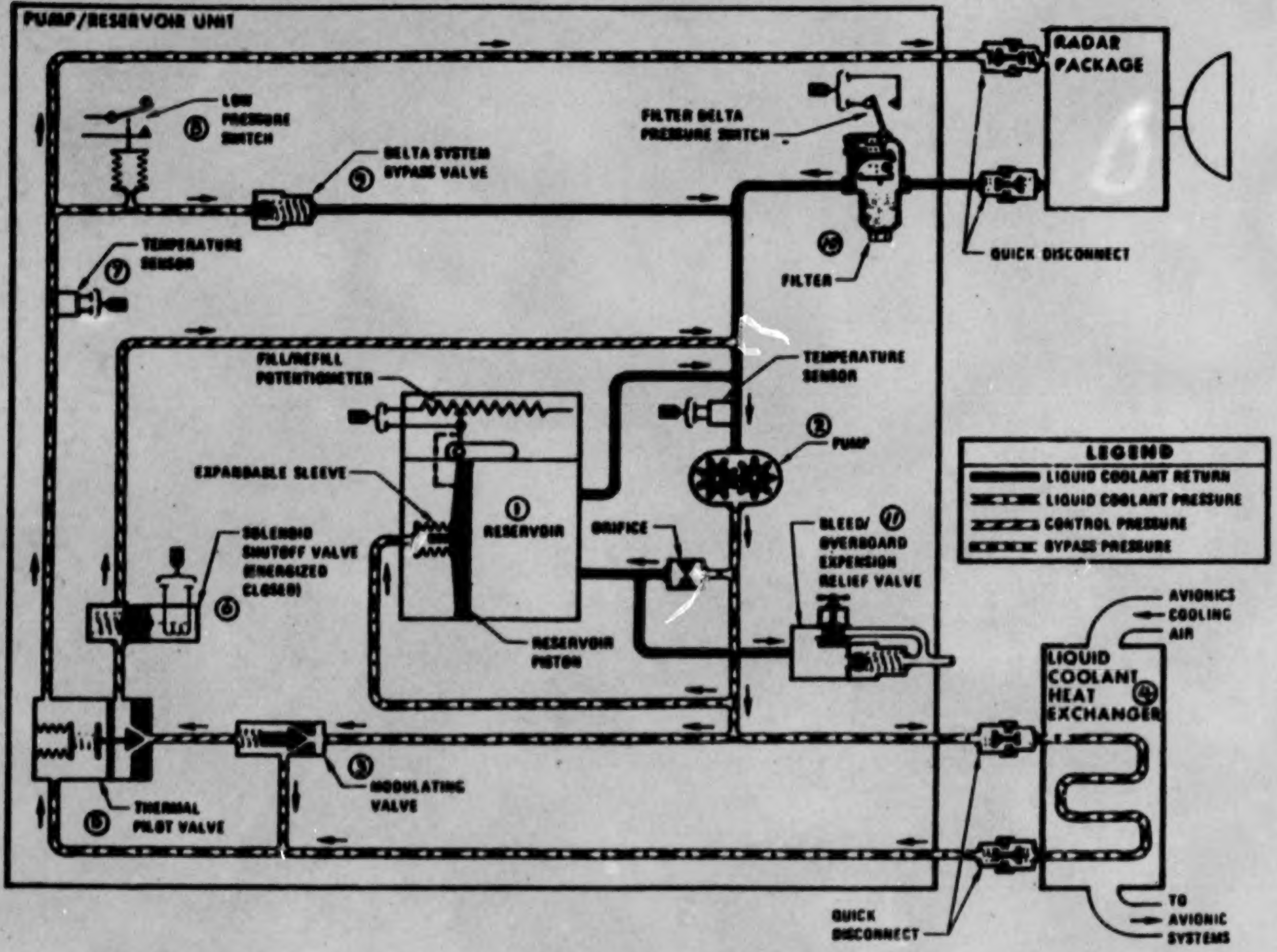

PUMP/RESERVOIR UNIT
⑧ LOW PRESSURE SWITCH
⑨ DELTA SYSTEM BYPASS VALVE
⑦ TEMPERATURE SENSOR
FILTER DELTA PRESSURE SWITCH
RADAR PACKAGE
⑩ FILTER
QUICK DISCONNECT
FILL/REFILL POTENTIOMETER
TEMPERATURE SENSOR
② PUMP
EXPANDABLE SLEEVE
① RESERVOIR
ORIFICE
BLEED/ ⑪ OVERBOARD EXPENSION RELIEF VALVE
SOLENOID SHUTOFF VALVE (ENERGIZED CLOSED) ⑥
RESERVOIR PISTON
LEGEND
LIQUID COOLANT RETURN
LIQUID COOLANT PRESSURE
CONTROL PRESSURE
BYPASS PRESSURE
AVIONICS COOLING AIR
LIQUID COOLANT HEAT EXCHANGER ④
⑤ THERMAL PILOT VALVE
③ MODULATING VALVE
QUICK DISCONNECT
TO AVIONIC SYSTEMS

FIGURE A LIQUID COOLANT SYSTEM SCHEMATIC

Answers to Frame 1: a. 8, b. 10, c. 11, d. 2, e. 6, f. 3,
g. 9, h. 1, i. 5, j. 7, k. 4

Frame 2

The reservoir is used to store the liquid. The reservoir holds 100 cubic inches (CI) of fluid and has a warning light that will come on when 20 CI or more of the fluid is lost. The reservoir is made up of three main parts which are (1) the housing, (2) the reservoir piston, and (3) the fill/refill potentiometer. The housing stores the liquid. The reservoir piston will keep a constant pressure of liquid supplied to the pump. This is done by the pressure of the liquid from the pump that is applied to the back of the reservoir piston. This pressure will allow only the needed liquid to be supplied to the system. The fill/refill potentiometer is connected to the reservoir piston. When the system has lost 20 CI or more of liquid the piston is moved to the right which will move the wiper of the potentiometer and turn on a warning light in the cockpit. This tells the pilot that the LCS is low on coolant.

Check the following statements that are true.

_____ 1. The warning light will come on in the cockpit when 10 or more cubic inches of fluid is lost.

_____ 2. The reservoir holds 100 cubic inches of coolant.

_____ 3. The warning light in the cockpit tells the pilot when the pressure in the reservoir is low.

Answers to Frame 2: _____ 1. __✓__ 2. _____ 3.

Frame 3

The pump is the next item in the LCS. The pump is a three phase, AC motor which operates all the time the radar unit is on. It keeps a constant pressure and flow through the LCS any time the system is operating.

The heat exchanger is the next item. This is where the heat is removed from the liquid coolant. The LCS heat exchanger is placed in the Avionics Cooling air ducting. The cooling air going to the Avionics Equipment is what cools the liquid in the LCS. The cooling air flows across the heat exchanger and LCS is routed through the heat exchanger. Once the cooling air removes the heat from the liquid it continues to the Avionics equipment. The small amount of heat that is picked up from the LCS will not affect the effectiveness of the Avionics cooling system. If the temperature of the liquid coolant is too cold, the coolant can bypass the heat exchanger. How the system bypasses the heat exchanger will be explained in the next frame.

Check the following statements that are true.

_____ 1. Ram air flowing across the LCS heat exchanger cools the liquid coolant.

_____ 2. The LCS pump is a 3 phase, AC motor, which operates any time the radar unit is on.

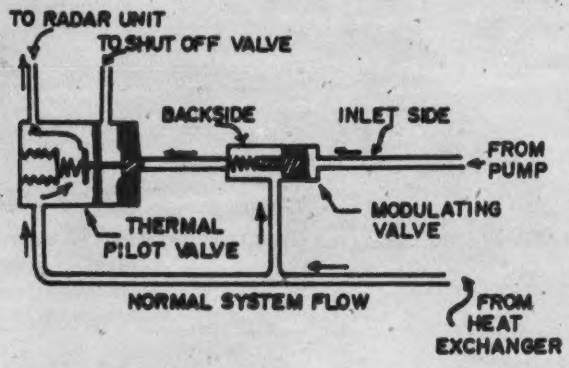
_____ 3. The purpose of the pump is to keep a constant pressure and flow through the LCS.

Answers to Frame 3: ____ 1. _✓_ 2. _✓_ 3.

Frame 4

During normal system operation (see figure B) fluid flows from the heat exchanger to the pilot valve. The pressure and temperature of the fluid entering the pilot valve positions the valve. When both the pressure and temperature are normal, the bellows of the pilot is expanded which forces the valve closed. With the pilot valve closed, pressure is trapped on the back side of the modulating valve. When pressure on the inlet side of the modulating valve is the same as the pressure on the back side, the valve will close. This is due to a spring installed in the back side of the modulating valve. It takes both the spring tension and the trapped pressure to close the valve. This allows the fluid to flow from the heat exchanger through the pilot valve and on to the radar unit.

Match the items in Column B to the statement


TO RADAR UNIT
TO SHUT OFF VALVE
BACKSIDE
INLET SIDE
FROM PUMP
MODULATING VALVE
THERMAL PILOT VALVE
NORMAL SYSTEM FLOW
FROM HEAT EXCHANGER

Match the items in Column B to the statement in Column A.

Column A		Column B	
1. ____	Fluid flows from heat exchanger to pilot valve.	a.	Modulating valve
2. ____	Pressure and temperature entering this valve positions it.	b.	Normal system operation
3. ____	It takes fluid pressure and spring tension to close this valve.	c.	Pilot valve
		d.	Spring tension

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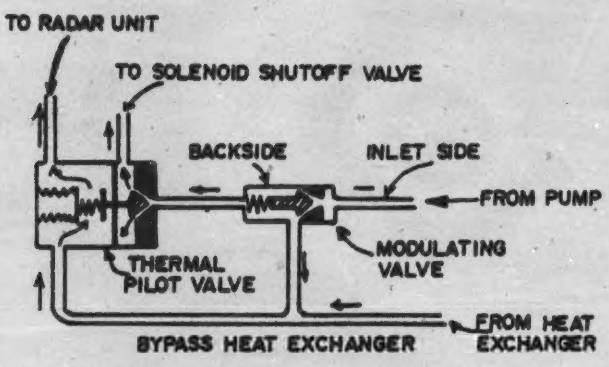
Answers to Frame 4: 1. b, 2. c, 3. a

Frame 5

When the temperature and pressure of the system decreases the modulating valve opens allowing the fluid to flow from the pump through the modulating pilot valve on to the radar unit. (See figure C.)


TO RADAR UNIT
TO SOLENOID SHUTOFF VALVE
BACKSIDE
INLET SIDE
FROM PUMP
MODULATING VALVE
THERMAL PILOT VALVE
FROM HEAT EXCHANGER
BYPASS HEAT EXCHANGER

As the temperature and pressure of the fluid entering the pilot valve decreases, the bellows in the pilot valve contracts (opens). This pulls the valve off its seat, allowing the trapped pressure between the modulating valve and the pilot valve to bleed off. The pressure on the inlet side of the modulating valve is higher than the back side pressure. This inlet pressure can override the spring in the modulating valve and force the valve off its seat. This allows the fluid to flow from the pump, through the modulating and pilot valves, to the radar unit, completely bypassing the heat exchanger.

Check the following statements that are true.

_____ 1. If the temperature and pressure of the liquid increased, the bellows in the pilot valve will expand and close the valve.

_____ 2. Closing the pilot valve will trap pressure on the back side of the modulating valve.

_____ 3. With the modulating valve open the fluid must flow through the heat exchanger.

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Answers to Frame 5: ✓ 1. ✓ 2. ___ 3.

Frame 6

Match the component in Column B to the statement that best describes it in Column A.

Column A

_____ 1. Keeps a constant pressure of liquid flowing from the reservoir to the pump.

_____ 2. Must be closed by fluid pressure and spring tension to direct the fluid through the heat exchanger.

_____ 3. 3 phase AC motor operated to provide a constant pressure and flow through the LCS.

_____ 4. Moved by the reservoir piston to indicate a loss of 20 CI or more of fluid from the reservoir.

_____ 5. Has a bellows that reacts to temperature and pressure changes and will open the modulating valve to bypass the heat exchanger.

Column B

a. Modulating valve

b. Pump

c. Reservoir piston

d. Pilot valve

e. Fill/refill potentiometer

f. Solenoid shutoff valve

Answers to Frame 6: c. 1. a. 2. b. 3. e. 4. d. 5.

Frame 7

The LCS has a two position master switch (normal and test). In the normal position, the solenoid shutoff valve is deenergized and opened. With the pilot valve also open, the pressure that is trapped between the pilot valve and the back side of the modulating valve will flow through the solenoid valve back to the pump return line. This means that the pilot and modulating valves are controlling the flow of coolant that goes through or bypasses the heat exchanger. The test position of the LCS switch is to let you perform an operational and leak check of the LCS on the ground. With the switch in the test position, the solenoid shutoff valve is energized closed. With the pilot valve open and the solenoid valve closed, pressure is trapped on the back side of the modulating valve. This keeps both the inlet and back side pressure equal, which keeps the modulating valve closed at all times. So no matter what the temperature of the coolant is, it has to go through the heat exchanger and cannot in any way bypass it. The maximum time you can run the LCS in test position is 6.5 minutes.

Check the following statements that are true.

_____ 1. The test position of the LCS master switch is used to operational and leak check the system on the ground.

_____ 2. The solenoid shutoff valve is energized closed.

_____ 3. When the LCS master switch is in the test position, the pilot and modulating valves are always closed.

_____ 4. When the LCS master switch is in the normal position, the flow of the liquid coolant is controlled by the pilot and modulating valves.

_____ 5. The maximum time the LCS can be operated in the test position is 6.5 minutes.

Answers to Frame 7: ✓ 1. ✓ 2. ____ 3. ✓ 4. ✓ 5.

Frame 8

The overtemperature sensor (7) is installed in the LCS between the thermal pilot valve and the low pressure switch. When the air flowing across the LCS heat exchange is not cold enough to remove the heat from the coolant flowing through the heat exchanger, the overtemperature sensor completes a circuit to the overtemperature warning light in the cockpit. If the warning light comes on, you have a malfunction in the cooling air system. The purpose of the sensor is to tell the pilot if the liquid coolant is too hot to cool the radar unit. If the overtemperature warning light comes on, the pilot must turn the radar unit off. With the radar unit off, the pilot must return to his base.

Check the following statements that are true.

____ 1. The overtemperature sensor is located between the pump and filter.

____ 2. If the overtemperature warning light comes on, it tells the pilot he has a malfunction in the modulating valve.

____ 3. When the overtemperature warning light is on, the pilot could operate the radar unit for 6.5 seconds.

____ 4. The pilot must turn the radar unit off and return to his base if the radar unit cannot be cooled.

3057

Answers to Frame 8: ____ 1. ____ 2. ____ 3. _✓_ 4.

Frame 9

The low pressure switch in the LCS is used to indicate if the liquid level is too low to cool the radar unit. When you have no pressure or low pressure, the low pressure switch is collapsed which makes an electrical circuit that will turn on the low pressure warning light in the cockpit. (See figure D.)

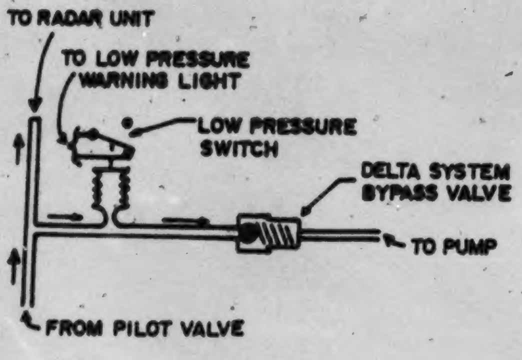
TO RADAR UNIT
TO LOW PRESSURE WARNING LIGHT
LOW PRESSURE SWITCH
DELTA SYSTEM BYPASS VALVE
TO PUMP
FROM PILOT VALVE

Figure D. Low System Pressure

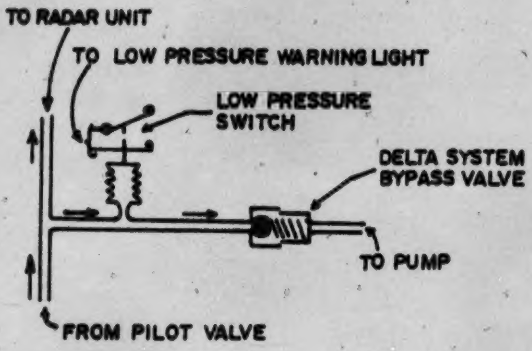
TO RADAR UNIT
TO LOW PRESSURE WARNING LIGHT
LOW PRESSURE SWITCH
DELTA SYSTEM BYPASS VALVE
TO PUMP
FROM PILOT VALVE

Figure E. Normal System Pressure

When the system is operating at normal system pressure, fluid enters an opening in the bottom of the low pressure switch, pushing the top of the switch up breaking the circuit to the warning light in the cockpit. (See figure E.)

Complete each of the following statements:

1. If the LCS is in the off position, the warning light will ________________________.

2. If the LCS is in the on position, the warning light will ________________________.

Answers to Frame 9: 1. stay on 2. go off

Frame 10

Now that you know what happens when you do not have enough pressure in the system, let's see what happens when you have too much pressure. The system bypass valve is spring-loaded to the closed position. The coolant flows from the pilot valve toward the radar unit. If the pressure is normal, fluid will flow to the ball of the bypass valve but the spring will hold the valve closed which lets all the fluid in the system flow to the radar unit. (See figure F.)

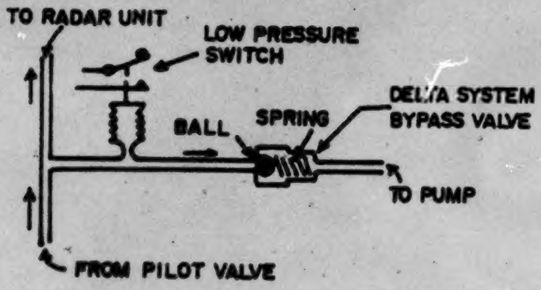
TO RADAR UNIT
LOW PRESSURE SWITCH
DELTA SYSTEM BYPASS VALVE
BALL
SPRING
TO PUMP
FROM PILOT VALVE

Figure F. Normal Pressure

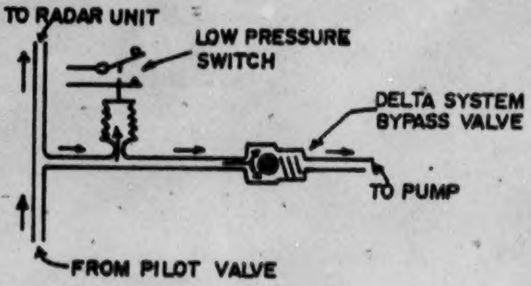
TO RADAR UNIT
LOW PRESSURE SWITCH
DELTA SYSTEM BYPASS VALVE
TO PUMP
FROM PILOT VALVE

Figure G. Excessive or High Pressure

If the pressure is too high, the pressure of the fluid pushes against the ball of the bypass valve. (See figure G.) As the pressure builds up, it overrides the spring tension of the bypass valve which forces the ball off its seat. This lets the high pressure bypass the radar unit and return the fluid to the line going to the pump.

Check the following statements that are true.

_____ 1. The system bypass valve is spring loaded to the closed position.

_____ 2. The bypass valve protects the system from high pressure.

_____ 3. The fluid that flows through the bypass valve is routed back to the pump, bypassing the radar unit.

Answers to Frame 10: __✓__ 1. __✓__ 2. __✓__ 3.

Frame 11

After the coolant leaves the radar unit, it must flow through some type of assembly to clean the fluid. This is called a filter and it is used to remove dirt, etc, from the fluid. The filter is made of a wire mesh element, housed in an aluminum bowl. There are two ways to tell you that the filter is dirty. One way is a mechanical pop-up indicator on the filter housing. When the filter is dirty, the pressure increases until it forces the pop-up indicator out. At the same time, this pressure is applied to the filter pressure switch which completes the circuit to the warning light in the cockpit.

The pilot must turn the radar unit off once the warning light has come on because there is no coolant flowing to the radar unit. You must remove and replace the filter element before the pop-up indicator or the warning light can be reset.

Match the component in Column B to the statement in Column A that best describes its use.

Column A

_____ 1. Complete an electrical circuit to a warning light to tell the pilot the filter is dirty.

_____ 2. Used to remove dirt from fluid as it leaves the radar unit.

_____ 3. Mechanical device that tells the filter is dirty.

Column B

a. Pop-up button

b. Wire mesh

c. Pressure switch

d. Aluminum bowl

3060

Answers to Frame 11: c. 1. b. 2. a. 3.

Frame 12

The bleed/overboard expansion relief valve is located just off the reservoir. This valve has two functions. The first one is to allow you to bleed air out of the LCS and drain the LCS completely. The bleed is a manual opened or closed valve. Turn the handle clockwise to close the valve and counterclockwise to open it. If air is trapped in the system, it has to be removed. This is because air will not conduct the heat as the coolant will. If the coolant gets dirty and you need to change it you need a place to drain it. The coolant is just like the oil in a car engine. It has to be drained and new coolant installed at regular intervals in order to protect the system. The second function of the valve is expansion relief. This portion of the valve will protect the reservoir from high pressure. It consists of a ball and spring. During normal system operation, pressure is applied to the ball of the valve but cannot offseat it because of the spring tension. When the pressure increases, it overrides the spring tension forcing the ball off seat and vents the high pressure overboard. This way the high pressure will be vented overboard and not damage the reservoir.

Complete each of the following statements.

1. The manual bleed handle must be turned ____________ to open the bleed valve.

2. The bleed portion of the bleed/overboard expansion relief valve is used to bleed __________ out of the system and ___________ the system completely.

3. The expansion relief portion of the valve is made up of a _________ and _______________.

4. To force the expansion relief valve open, the coolant pressure must increase and override the ___________ ________________.

3061

Answers to Frame 12: 1. counterclockwise 2. air drain

3. ball spring 4. spring tension

Frame 13

Refer to figure A on page 4. Place the number of the component from figure A in the blank space alongside the statement that best describes its function or operation in the Liquid Cooling System.

_____ 1. The temperature and pressure of the liquid entering this valve will determine what route the liquid will take.

_____ 2. When this valve is open, the liquid bypasses the heat exchanger.

_____ 3. Picks up a high temperature indicator and turns on a warning light in the cockpit to let the pilot know about the condition.

_____ 4. Starts the flow of liquid through the system when the radar unit is turned on.

_____ 5. Indicates that the liquid level is too low to cool the radar unit.

_____ 6. Protects the reservoir from excess pressure.

_____ 7. Used to remove dirt, etc., from the liquid as it leaves the radar unit.

_____ 8. A spring loaded bypass valve that will relieve excess system pressure.

_____ 9. Contains a manually operated valve that can be used to bleed air out of the system and drain the liquid from the system.

_____ 10. A solenoid valve that allows for an operational and leak check of the Liquid Cooling System while the aircraft is on the ground.

Answers to Frame 13:

If you have missed any of the items, review the frame given for that item.

1.	5	Frame 4
2.	3	Frame 5
3.	7	Frame 8
4.	2	Frame 3
5.	8	Frame 9
6.	11	Frame 12
7.	10	Frame 11
8.	9	Frame 10
9.	11	Frame 12
10.	6	Frame 7

3062

PROGRAMMED TEXT
3ABR42331-PT-407A

Technical Training

Aircraft Environmental Systems Mechanic

LIQUID CYCLE REFRIGERATION SYSTEM

31 October 1977

3350 TECHNICAL TRAINING WING
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

FOREWORD

This programmed text was prepared for use in the 3ABR42331, Aircraft Environmental Systems Mechanic Course. The materials contained herein were validated with students from the subject course. At least 90% of the students taking this text achieved or surpassed the criteria established in the lesson objective. The average time for completion of this text was two hours 30 minutes.

OBJECTIVES

Relate eight (8) of ten (10) components of a liquid coolant and liquid cycle refrigeration system to its operation.

INSTRUCTIONS

This programmed text is divided into small sections called frames. Each frame contains information that you are required to know in order to satisfactorily complete the above listed objective. At the end of each frame there will be a form of questioning to which you will be required to respond in some manner. The correct answer(s) will be found at the end of the following frame. Due to the length of this programmed text, be certain you understand each frame before proceeding to the next.

Proceed to Frame 1

OPR: 3370TTG
DISTRIBUTION: X
3370TTGTC - 250; TTVSR - 1

The term air conditioning means "controlling the temperature, circulation, humidity, and purity of the air." A system which does only one or two of these functions is not considered to be a true air conditioner. The Air Force equipment which you maintain will do one, two or possibly three of these functions. Due to popular usage, these cooling units are all referred to as "air conditioners."

On the next page you will find a glossary of terms and definitions used throughout the text.

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GLOSSARY

AMBIENT AIR: The air surrounding an object.

ATMOSPHERIC PRESSURE: Pressure at sea level. It is expressed in 14.696 pounds per square inch absolute pressure.

BOILING POINT: The temperature at which a liquid vaporizes upon addition of heat. The boiling point will depend upon the pressure exerted upon the surface of the liquid.

BTU (BRITISH THERMAL UNIT): The amount of heat required to raise the temperature of one pound of water one degree Fahrenheit.

BY-PASS: A connection around a coil for the purpose of reducing the capacity of the coil.

BY-PASS, HOT GAS: A connection from the discharge side, directly to the suction side of a compressor. Sometimes used as a means of capacity control.

CAPACITY: It is the refrigerating effect produced and generally measured in BTUs or tons per hour.

CAPILLARY TUBE: A tube having a very small internal and external diameter. They are used to connect the thermal bulb to the upper diaphragm chamber of an expansion valve and remote temperature controllers.

CHANGE OF STATE: A change in the physical characteristic of a substance. For example, the change from a liquid to a gas.

CONDENSE: To change state from a gas to a liquid.

CONDENSER: An arrangement of pipes or tubing in which the vaporized refrigerant is liquified by the removal of heat.

CONDUCTION: Heat transfer by contact of two substances.

CONVECTION: Heat transfer by movement of fluid or air.

CRITICAL TEMPERATURE: Temperature of a gas above which it cannot be liquified by pressure alone, regardless of the amount applied.

CUT-IN POINT: The temperature or pressure at which a controller will function to start the equipment controlled.

CUT-OUT POINT: The temperature or pressure at which a controller will function to stop the equipment controlled.

CYCLE: Complete course of operation of refrigerant back to a starting point, also used in general for any repeated process of a system.

DUMP VALVE: A valve used for controlling air flow.

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DRIER: A device containing a desiccant for the purpose of removing moisture from a refrigerant.

DISCHARGE PRESSURE (HIGH SIDE PRESSURE): Operating pressure measured at the outlet of the compressor.

EQUALIZER, EXTERNAL: A tube connecting the chamber under the diaphragm of the thermostatic expansion valve to the outlet of the evaporator. Eliminate the effect of pressure drop through the evaporator on superheat response.

EQUALIZER, INTERNAL: The port connecting the chamber under the diaphragm of the thermostatic expansion valve to the suction side of the valve passage.

EVAPORATION: The process of converting liquid to a gas.

EVAPORATOR: Any device in which a refrigerant is evaporated for the purpose of extracting heat from the surrounding medium.

EXPANSION VALVE: A device designed to meter the flow of liquid refrigerant to an evaporator.

FLASH GAS: Gas generated whenever pressure is reduced on a liquid held at boiling temperature.

FLOODBACK: A carry-over of liquid refrigerant from the evaporator to the suction line.

FUSIBLE PLUG: A safety device having an insert of low melting alloy. At excessive temperature the alloy will melt, and release the refrigerant.

HEAT EXCHANGER: Any device which removes heat from one fluid and adds it to another.

HEAT, LATENT: Heat added or removed which cannot be measured by a change in temperature but causes a change in state.

HUMIDITY, RELATIVE: The amount of moisture in the air stated in terms of percentage of total saturation at the existing dry bulb temperature.

LINE, DISCHARGE: Refrigerant piping or tubing between the compressor and condenser.

LINE, LIQUID: Refrigerant piping or tubing between the receiver and expansion valve.

LOAD, HEAT: The amount of heat per unit time imposed on a refrigerant system or the required rate of heat removed.

LOW SIDE (SUCTION SIDE): Parts of a refrigerant system in which the refrigerant pressure corresponds to the evaporator pressure.

OIL PRESSURE FAILURE SWITCH: A device which acts to shut off a compressor when oil pressure falls below a predetermined point.

PRESSURE: The force exerted upon a liquid or gas in a confined area.

PRESSURE DROP: The loss of pressure due to friction.

PUMPDOWN: The reduction of pressure within a system.

PURGE: The discharge of impurities, noncondensibles, or gases, or an overcharge of refrigerant into the atmosphere.

RECEIVER: A device for storing liquid refrigerant.

REFRIGERATION SYSTEM: A system in which a refrigerant is circulated for the purpose of extracting heat.

SENSIBLE HEAT: Heat added or removed which can be measured by a change in temperature.

SIGHT GLASS: A glass installed in the liquid line permitting visual inspection of the liquid refrigerant.

SUBCOOLING: The cooling of a liquid below its condensing temperature.

SUCTION LINE: Tubing or piping which connects the evaporator to the compressor.

SUPER HEAT: Temperature added to a substance above its boiling point.

TEMPERATURE, AMBIENT: The temperature of surrounding air.

TON OF REFRIGERATION: A unit of refrigeration capacity. Equal to 12,000 BTUs per hour or 288,000 BTUs per 24 hours.

USEFUL OIL PRESSURE: The difference in pressure between suction pressure and compressor oil pressure.

VACUUM: A reduction in pressure below atmospheric pressure.

VAPOR: A fluid in the gaseous state following evaporation.

VALVE, PURGE: A valve through which noncondensible gases or an over-charge of refrigerant may be purged from a condenser or receiver.

Frame 2

To put it in simple language, refrigeration and air conditioning are ways through which temperatures are reduced. Whatever the substance--solid, liquid, or gas--the process used to reduce its temperature is called refrigeration. In other words, it may be said that refrigeration is a way of removing heat from a substance when this heat is not wanted; then transferring it to another substance where it is not objectionable. For example, if the air of a room is too warm and some of the heat can be removed and transferred to another place, the way it is done would be called refrigeration or air conditioning.

Complete the statements in column A by placing the letter from column B in the space provided.

	Column A		Column B
_____1.	Refrigeration or air conditioning is the process of	a.	a reduced temperature.
		b.	adding heat.
_____2.	The change in temperature by removing the heat is called	c.	refrigeration or air conditioning.
		d.	removing and transferring heat.
_____3.	The result of air conditioning or refrigeration is		

Answer to Frame 1: No Response Required.

3069

Frame 3

The law that controls the transfer of heat points out that heat can be moved from a hot substance to a cool substance until both are the same temperature. Then there will be no transfer of heat. The rate at which heat will move from one substance to another will rest on the temperature difference of the two substances. The greater the temperature difference, the faster the rate of heat transfer. As the temperature difference becomes less, the rate of transfer will decrease and will stop when there is no temperature difference.

Heat can be transferred by any one of three methods: conduction, convection, or radiation. These methods and their principles will be gone over in the frames that follow.

Answer the questions in column A by placing the letter from column B in the space provided.

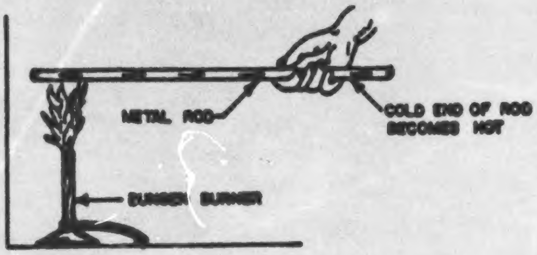
	Column A		Column B
____1.	Which of the temperature groups has the most rapid rate of heat transfer?	a.	+32°F and +60°F
		b.	0°F and 0°F
____2.	Which one of the temperature groups has the slowest rate of heat transfer?	c.	-32°F and +32°F
		d.	+1000°F and +950°F
____3.	Which two temperature groups has no heat transfer?	e.	+68°F and +68°F
		f.	+30°F and +62°F

Answers to Frame 2: d 1. c 2. a 3.

3070

Frame 4

When heat is transmitted from one part of a solid substance to another part of the same substance (see illustration below), or in direct contact from one solid substance to another solid substance, it is referred to as heat transfer by conduction.



Place a T (true) or F (false) in front of the statements below.

____1. When one end of an iron bar is heated and the opposite end becomes warm, the transfer of heat is due to conduction.

____2. Warm air from a furnace heat duct is referred to as heat transfer by conduction.

____3. Heat felt over glowing charcoal in a barbecue grill is referred to as heat transfer by conduction.

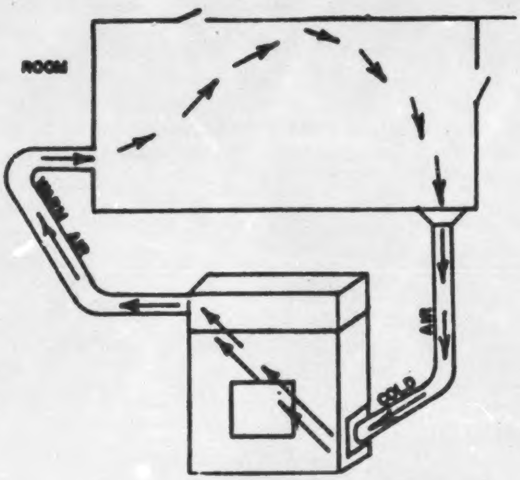
____4. When a solid substance that has been heated comes into direct contact with a cool solid object, and the cool object then becomes warm, the transfer is by conduction.

Answers to Frame 3: c 1. a 2. b & e3.

3071

Frame 5

One of the methods of heat transfer that most of us are familiar with is called convection. This refers to any heat transferred by means of the movement of gas or liquids. When air (a mixture of gases) is heated, it expands and becomes lighter, which will cause it to rise. As the air becomes cold and heavy, it flows back to the source of heat where it is again heated. Thus, a circulation of air is set up that will continue as long as heat is provided. Look at the sketch below.



Place a T (true) or F (false) in front of the appropriate statements below.

_____1. Heat felt in water coming from a hot water faucet is heat transfer by convection.

_____2. Heat felt over glowing charcoal in a barbecue grill is referred to as heat transfer by convection.

_____3. Warm air coming from a furnace heat duct is referred to as heat transfer by convection.

_____4. Heat transfer through a solid is referred to as convection.

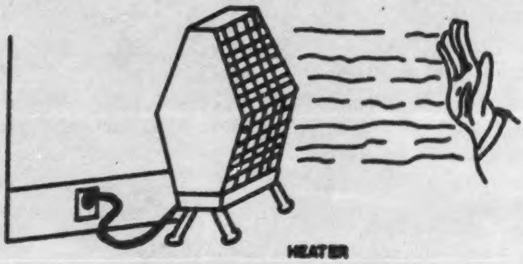
Answers to Frame 4: __T__ 1. __F__ 2. __F__ 3. __T__ 4.

458

3072

Frame 6

The other mode of heat transfer is referred to as radiation. This means that the heat is moved by rays as shown in the following sketch. In this case, a person's hand feels warm, though it is quite a distance from the source of heat. The rays pass through the air and heat the hand more than the air between the hand and heater. A good example of radiation is the rays from the sun heating our earth.



Place a T (true) or F (false) in front of the statement below.

_____1. Transferring heat by means of warm air is a form of radiation.

_____2. The movement of heat through a solid is a form of radiation.

_____3. Heat felt in water coming from a hot water faucet is heat transfer by convection.

_____4. Heat felt over glowing charcoal in a barbecue grill is heat transfer by radiation.

Answers to Frame 5: __T__ 1. __F__ 2. __T__ 3. __F__ 4.

3073

Frame 7

Heat intensity, or how warm a substance is, will be checked through the use of a thermometer, and the unit of measurement is called the degree. A change in temperature can be found by the thermometer, and also can be sensed by touch.

Sensible heat is referred to as heat that will cause a temperature change and can be checked with a thermometer. For example, an iron rod that is heated to 72°F then cooled to 40°F will show sensible heat loss of 32° (72°F minus 40°F equals 32°F difference).

Another form of sensible heat is super heat. This is known as heat added to a substance that is in its gaseous state. For example, water will change to steam at 212°F at sea level pressure, and the steam can then be heated to 250°F or higher. The sensible heat temperature difference between 250°F and 212°F is 38°F in the form of super heat gained while the water is a vapor. Super heat is extremely important in controlling the conditioned air temperature.

Complete the statements in column A by placing a letter from column B in the space provided. NOTE: More than one response may be used per statement.

Column A	Column B
____1. Changing the temperature of a substance is caused by adding	a. latent heat.
	b. sensible heat.
____2. Degrees--the unit of measurement for	c. specific heat.
	d. super heat.
____3. The thermometer will measure	e. an increase in latent heat.
____4. Sensible heat added to a substance will cause	f. a change of state.
	g. a temperature change.
	h. heat intensity.

Answers to Frame 6: _F_ 1. _F_ 2. _T_ 3. _T_ 4.

3074

Temperature is defined as heat intensity, or, the heat level of a substance. Heat intensity is expressed in degrees and measured with a thermometer. The Fahrenheit scale is used in this country to measure refrigeration temperatures, so all measurements will be expressed in degrees Fahrenheit.

The term used to express heat quantity (amount) is the British Thermal Unit (BTU). Specifically, a single BTU is the amount of heat required to raise one pound of water one degree Fahrenheit. Two BTUs added to a pound of water will cause an increase of 2°F. The BTU is used to express the amount of heat an air conditioner is capable of removing. A 12,000 BTU air conditioner is capable of removing 12,000 BTUs in one hour.

Place a T (true) or F (false) in front of the statements below.

_____1. Temperature is a measure of heat intensity.

_____2. Heat intensity is expressed in degrees.

_____3. Heat quantity is expressed in BTUs.

_____4. A BTU is the amount of heat required to raise the temperature of one pound of water one degree Fahrenheit.

Complete the statements in column A by placing the letter from column B in the space provided.

	Column A		Column B
_____5.	Heat intensity is another name for	a.	super heat.
		b.	degrees.
_____6.	Heat intensity is expressed in	c.	temperature.
_____7.	The British Thermal Unit (BTU) is used to express	d.	sensible heat.
		e.	heat quantity.

Indicate the true statements by placing a checkmark in the space provided.

_____8. Two BTUs will raise 2 pounds of water 1 degree.

_____9. It would require 6 BTUs to raise 3 pounds of water 9°F.

____10. Five BTUs will raise 1 pound of water 5°F.

Answers to Frame 7: __b__ 1. __b,d__ 2. __b,g,d__3. __g__ 4.

461

3075

Frame 9

Water will boil at 212°F at sea level pressure. To bring water to its boiling point, heat must be applied to raise its temperature. The water temperature will raise until it reaches 212°F. When water boils, it gives off a water vapor in the form of steam. (Boiling water is water that undergoes a change of state from a liquid to a gas.) After reaching its boiling point, the temperature of the water will not increase, and cannot be measured as a change in temperature even though the heat is still applied. It will stay at 212°F until all of the water is changed to steam. This hidden heat is called LATENT HEAT, and this term refers to heat gained or lost by a substance when it has a change of state (from solid to liquid, liquid to gas, gas to liquid, or liquid to solid).

Complete the statements in column A by placing the letter from column B in the space provided. Some responses will be used more than once.

Column A

____1. When changing from a liquid to a gas, a substance absorbs

____2. When latent heat is added or removed, there will be no

____3. The thermometer will not measure

____4. Super heat is a form of

Column B

a. sensible heat.

b. latent heat.

c. change of state.

d. change of temperature.

e. super heat.

f. conduction.

Answers to Frame 8: T 1. T 2. T 3. T 4. c 5.

b 6. e 7. ✓ 8. ____9. ✓ 10.

Frame 10

SPECIFIC HEAT is defined as the amount of heat (in BTUs) that is used to raise one pound of a substance one degree Fahrenheit.

Water is used as the standard from which all specific heats are ranked. If any kind of solid, liquid, or gas takes more or less heat than water to raise its temperature one degree Fahrenheit, that percentage or ratio is known as its specific heat. One pound of water needs the use of 1 BTU (British Thermal Unit) to raise its temperature one degree. Carbon dioxide, for example, takes the use of only .6 BTUs to raise its temperature one degree. This means that carbon dioxide soaks up heat more readily than water because it needs less than one BTU to raise its temperature one degree.

Complete the statements in column A by placing the letter from column B in the space provided.

Column A

_____1. Specific heat of a substance

_____2. Water is the standard used when figuring

_____3. Sensible heat is referred to as the heat which

_____4. Carbon dioxide boils at -109.3°F. If its temperature were increased to -87°F, the temperature difference would be a form of sensible heat called

Column B

a. causes a change of state.

b. is the amount of heat required to raise the substance one degree Fahrenheit.

c. causes a change of temperature.

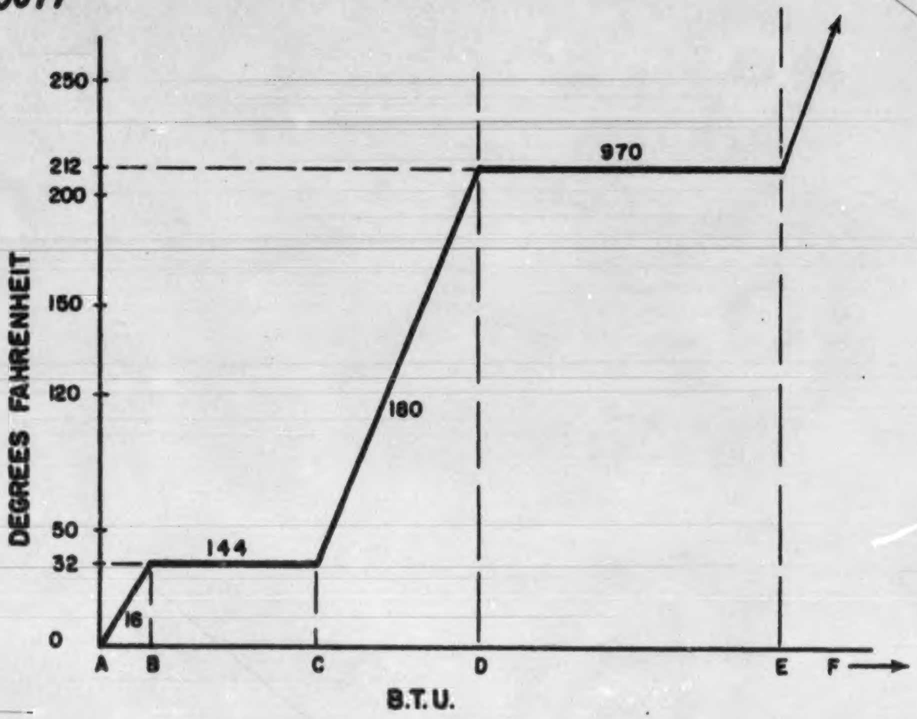
d. specific heat values.

e. super heat.

f. sensible heat values.

Answers to Frame 9: __b__1. __d__2. __b__3. __a__4.

3077



A-B to heat ice from 0° to 32° (Sensible Heat)	16 BTU
B-C to melt ice 32° to 32° (Latent Heat)	144 BTU
C-D to heat water from 32° to 212° (Sensible Heat)	180 BTU
D-E to change water to steam 212° to 212° (Latent Heat)	970 BTU
E-F to heat steam to desired temperature in closed vessel (Super Heat)	
The amount of BTUs required to change one pound of 0°F ice to 212°F Steam	1310 BTU

Chart 1.

Frame 11

All matter can be found in either a solid, liquid, or gaseous state and most can be changed from one state to another. While changing from one state to another, the material must gain or lose heat.

To change a liquid to a gas (boiling), the liquid must take in a great amount of heat (BTUs). For example, to change one pound of 212°F water to 212°F steam will take 970 BTUs (see chart 1). At atmospheric pressure, this change (liquid to gas) needs the greatest amount of BTUs to cause the change. We use this characteristic in refrigeration to take heat from the air. Changing a gas to a liquid (condensing) is an equally important change of state used in refrigeration. By removing the heat taken in while changing the refrigerant from liquid to gas, we can convert the gas back to its liquid state and start the cycle again.

Complete the statements in column A by placing the letter from column B in the space provided.

Column A

_____1. To cause a change of state, a material must

_____2. Changing from liquid to gas, a material must

_____3. Changing from gas to a liquid, a material must

_____4. The thermometer will not measure

_____5. How many BTUs are required to change 1 pound of 32°F ice to 32°F water? Use illustration 2A in HO-601.

Column B

a. lose sensible heat.

b. gain latent heat.

c. gain sensible heat.

d. lose latent heat.

e. gain or lose heat.

f. latent heat.

g. 180 BTUs.

h. 144 BTUs.

i. 16 BTUs.

Answers to Frame 10: __b__ 1. __d__ 2. __c__ 3. __e__ 4.

3079

Frame 12

The boiling point of water at sea level pressure (14.7 psia) is 212°F. Water can be made to boil at a different temperature by changing the pressure. See the following chart. A decrease in pressure will cause the boiling point to be lower (for example, when the pressure is reduced to 7.5 psia*, water will boil at 180°F, where it needs less heat to boil). An increase in pressure will cause the boiling point to raise. If the pressure is raised to 20.7 psia, water will boil at 230°F (where it needs much more heat to boil).

Any increase in heat when a liquid is boiling will only cause the boiling rate to increase (boil faster). This rule is true for all liquids and is used in refrigeration to control the boiling and condensation points of the refrigerants.

180	7.51
190	9.34
200	11.53
210	14.12
212	14.70
215	15.79
220	17.19
230	20.78
240	24.97
250	29.82

Temperature-Pressure Relation for Boiling Water.

*psia -- pounds per squre inch absolute.

Place a checkmark (✓) in front of the correct statement(s) below.

_____1. Raising the pressure on a liquid will require less heat for the liquid to boil.

_____2. Lowering the pressure on a liquid will require more heat for the liquid to boil.

_____3. Lowering the pressure on a liquid will cause the liquid to boil at a lower temperature.

_____4. Lowering the pressure on a liquid will cause the liquid to boil at a higher temperature.

Answers to Frame 11: __e__1. __b__2. __d__3. __f__4. __h__5.

3080

The temperature and pressure that will cause a gas to change to a liquid is called the condensing point. The condensing point can also be made to take place at a different temperature by a change in pressure. An increase in pressure will cause a gas to condense at a higher temperature. A decrease in pressure will cause a gas to condense at a lower temperature. When a gas does change to a liquid, it must give out the same amount of heat that was soaked up in the change to a gas. The rate (speed) that a gas will turn to a liquid can be controlled by controlling the temperature of the substance used to carry the heat away. The most common substances used to remove heat, to condense a gas, are air and water.

Complete the statements in column A by placing the letter from column B in the space provided.

Column A

____1. To condense at a lower temperature

____2. Increasing the temperature of the substance carrying away the heat

____3. To cause condensation

____4. Increasing the pressure will cause a substance in its gaseous state to

Column B

a. will decrease the condensing rate.

b. the material must give up less heat than was absorbed changing to a gas.

c. will increase the condensing rate.

d. the pressure must be reduced.

e. the substance must give up the same amount of heat absorbed while changing to a gas.

f. condense at a higher temperature.

g. condense at a lower temperature.

Answers to Frame 12: ____1. ____2. _✓_3. ____4.

3081

Frame 14

When selecting an air conditioning unit, the heat load must be known. The ambient (surrounding) air temperature, the amount of air to be cooled, and the amount of moisture in the air (humidity) are conditions which make up the heat load. An increase in any of the above factors puts an additional load on the unit, and reduces its efficiency. Heat load and unit cooling capacity are expressed in BTUs or tons. A unit rated at one ton means that it has the capability of removing 12,000 BTUs per hour. (Refer to the chart below.)

BTU per hour	Tons
24,000	2
12,000	1
9,000	3/4
6,000	1/2

Complete the statements in column A by placing the letter from column B in the space provided. Use the chart as necessary.

Column A	Column B
_____1. Reducing the amount of air to be cooled	a. any of the heat load factors is reduced.
_____2. Any unit will be more efficient if	b. increases the heat load.
	c. decreases the heat load.
_____3. A unit capable of removing 54,000 BTUs is equal to (quantity)	d. any of the heat load factors is increased.
_____4. A unit capable of removing 138,000 BTUs is equal to (quantity)	e. 6 1/4 tons.
	f. 12 tons.
	g. 4 1/2 tons.
	h. 11 1/2 tons.

Answers to Frame 13: _d_ 1. _a_ 2. _e_ 3. _f_ 4.

In an air conditioning unit, the liquid used for cooling is called the "refrigerant". A refrigerant is any substance which is used for the purpose of removing and transferring heat. Materials with low boiling points are better suited for refrigerants than ones with high boiling points. The most common refrigerant used in Air Force air conditioning equipment is Freon 12, which has a boiling point of -21.7°F at sea level pressure. When this fact is related to water (boiling point 212°F at sea level pressure), it is plain to see that Freon 12 can absorb heat at very low temperatures. Freon 12 (R-12) is kept in the liquid state at normal room temperatures by storing it in steel cylinders under pressure.

Select the true statements by placing a (T) in the space provided.

_____1. A refrigerant is any material used to absorb and transfer heat.

_____2. A substance with a high boiling point is well suited for air conditioning.

_____3. To prevent R-12 from boiling at room temperature, it must be kept under pressure.

_____4. A liquid used for cooling air is referred to as a refrigerant.

Answers to Frame 14: __c__1. __a__2. __g__3. __h__4.

3083

Frame 16

A good refrigerant should have as many of the following properties as possible:

1. Low boiling point.

2. Low condensing pressure so that air-cooled condensers can be used.

3. Non-toxic.

4. Non-flammable.

5. Will not affect the lubricating oil.

6. Non-corrosive.

Regardless of the type refrigerant used, there are always some precautions which should be observed. When working with R-12, the operator must observe the following precautions:

1. Always insure adequate ventilation.

2. Always wear face shields or goggles.

3. Store cylinders in a cool, dry area away from flammable materials.

4. Refrigerant cylinders should be chained upright in storage and have protective caps over the valves.

NO RESPONSE REQUIRED.

Answers to Frame 15: _T_ 1. ____ 2. _T_ 3. _T_ 4.

3084

Frame 17

Complete the statements below by circling the correct response.

1. Refrigeration or air conditioning is the process of

   a. adding heat.

   b. circulating humidity.

   c. purifying air.

   d. removing and transferring heat.

2. Which of the following temperature groups has the most rapid rate of heat transfer?

   a. 52°F and 62°F.

   b. -32°F and +32°F.

   c. 800°F and 850°F.

   d. 212°F and 240°F.

3. When a solid object is heated and the opposite end becomes warm, the transfer of heat is due to

   a. convection.

   b. conduction.

   c. radiation and convection.

   d. conduction and radiation.

4. Warm air coming from a furnace heat duct is referred to as heat transfer by

   a. convection.

   b. conduction.

   c. radiation and convection.

   d. radiation and conduction.

5. Heat felt from the sun is referred to as heat transfer by

   a. convection.

   b. radiation.

   c. conduction.

   d. thermal rays.

3085

Frame 17 (Cont'd)

6. Changing the temperature of a substance is caused by adding

   a. super heat.

   b. latent heat.

   c. specific heat.

   d. sensible heat.

7. When the term "degree" is used, it indicates

   a. heat quantity.

   b. heat intensity.

   c. heat amount.

   d. heat values.

8. Three BTUs will raise 3 pounds of water

   a. one degree.

   b. three degrees.

   c. six degrees.

   d. nine degrees.

9. Heat gained or lost by a substance during a change of state is referred to as

   a. super heat.

   b. sensible heat.

   c. latent heat.

   d. specific heat.

10. The percentage of any substance requiring more or less heat than water to raise its temperature one degree Fahrenheit is called

   a. specific heat.

   b. super heat.

   c. latent heat.

   d. sensible heat.

472

11. Changing from a liquid to gas, a material must

    a. gain latent heat.

    b. gain sensible heat.

    c. lose latent heat.

    d. lose sensible heat.

12. An increase in pressure will

    a. require less heat for water to boil.

    b. require more heat for water to boil.

    c. cause the boiling point to be lower.

    d. none of the above.

13. Which of the following statements is true?

    a. Raising the pressure on a liquid will require less heat for the liquid to boil.

    b. Lowering the pressure on a liquid will require more heat for the liquid to boil.

    c. Lowering the pressure on a liquid will cause the liquid to boil at a lower temperature.

    d. Lowering the pressure on a liquid will cause the liquid to boil at a higher temperature.

14. To cause condensation,

    a. the pressure must be reduced.

    b. the temperature must be increased.

    c. the material must give up less heat than was absorbed in changing to a gas.

    d. the substance must give up the same amount of heat absorbed in changing to a gas.

Frame 17 (Cont'd)

15. The heat load is determined by

    a. ambient air temperature.

    b. amount of air to be cooled.

    c. humidity.

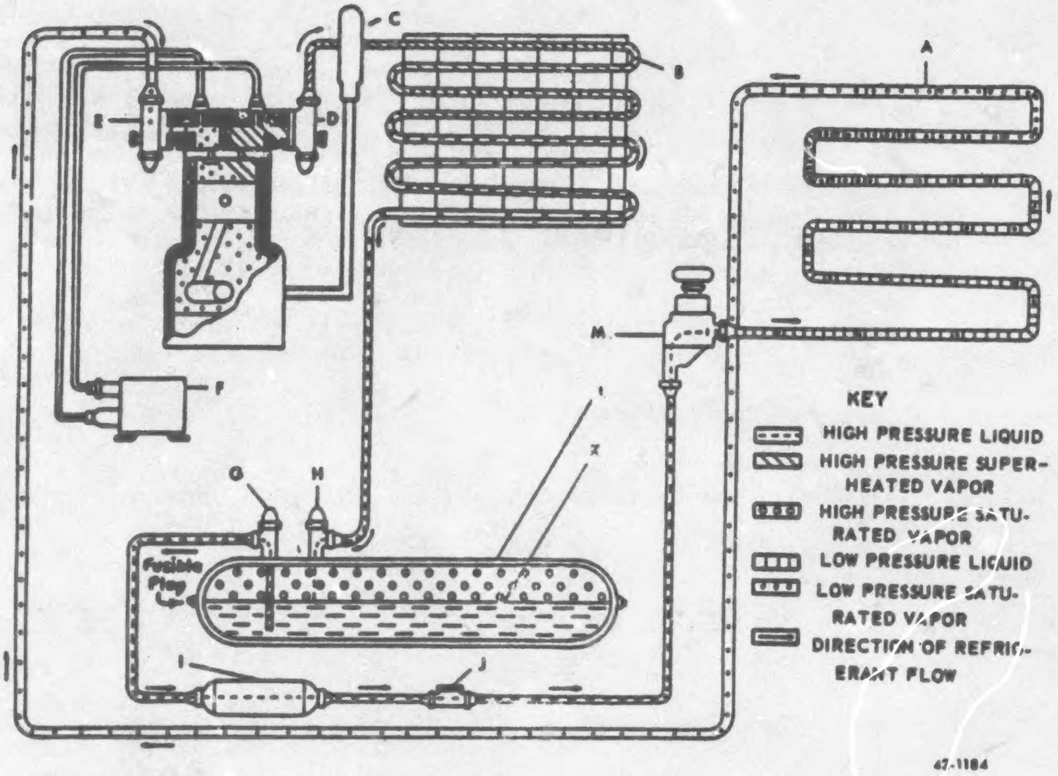
    d. all of the above.

Answers to Frame 17:

If you answered any of the statements incorrectly, review the following frames.

QUESTION NUMBER	ANSWERS	REVIEW FRAMES
1	d	2
2	b	3
3	b	4
4	a	5
5	b	6
6	d	7
7	b	8
8	a	8
9	c	9
10	a	10
11	a	11
12	b	12
13	c	12
14	d	13
15	d	14

3088


C
B
A
E
D
M.
F
G
H
K
L
Fusible Plug
I
J
KEY
HIGH PRESSURE LIQUID
HIGH PRESSURE SUPER-HEATED VAPOR
HIGH PRESSURE SATU-RATED VAPOR
LOW PRESSURE LIQUID
LOW PRESSURE SATU-RATED VAPOR
DIRECTION OF REFRIG-ERANT FLOW
47-1184

a. Evaporator.
b. Condenser.
c. Oil separator.
d. Discharge service valve.
e. Suction service valve.
f. Compressor switch.
g. Receiver outlet valve.

h. Receiver inlet valve.
i. Dehydrator.
j. Sight glass.
k. Liquid refrigerant.
l. Receiver.
m. Expansion valve.

Figure 1.

3089

Frame 18

The refrigeration system has five basic components--receiver, expansion valve, evaporator, compressor and condenser (look at figure 1). As the refrigerant flows through these components, it will go through changes in its pressure and state. All refrigeration and air conditioning units have a high and low pressure side, each side having a distinct function. The cooling of ambient air takes place in the low pressure side (evaporator), where the refrigerant changes state (low pressure liquid to a low pressure gas). The refrigerant boiling at a low temperature under low pressure absorbs heat from the ambient air.

The high side of the system provides the conditions to condense and store the liquid refrigerant. The compressor increases the pressure and temperature of the low pressure gas to a point at which it can be changed to a liquid. As the high pressure gas flows through the condenser, the heat is released to the ambient air. As heat is given off by the high pressure gas, it will return to its liquid state. The five basic components will be explained in detail later.

Complete the statements below by filling in the blanks with the correct terms.

1. In a refrigeration system, the components where the refrigerant changes state are the ______________ and ______________.

2. The low pressure side of a refrigeration system is where the ______________ takes place.

3. The refrigerant is liquified and stored in ______________ ______________ ______________.

4. The refrigerant in the condenser is liquified by ______________ ______________.

476

Frame 19

When the refrigeration system is not in operation, the liquid refrigerant is stored in the receiver. (Look at figure 1, item 1 for the location of the receiver in the system.) The receiver is a steel tank and should never be completely filled with liquid. Eighty (80) percent liquid is the general rule when filling the receiver.

The Temperature Pressure Chart was devised from this general rule (see figure 2). The remaining 20% of the tank is used to allow the refrigerant to expand and contract when the outside temperature changes. As the ambient temperature increases, pressure in the tank also increases. An ambient temperature of 90°F will result in a pressure of 100 psig in the tank (look at figure 2).

If the outside temperature decreases, some of the gas will condense and reduce the pressure. An 80°F ambient temperature will result in 84 psig in the receiver.

Complete the statements in column A by placing the letter from column B in the space provided. Some responses may be used more than once.

Column A	Column B
_____1. The pressure in the receiver is determined by the	a. size of the receiver.
	b. ambient air temperature.
_____2. A rise in ambient temperature will cause	c. condensation in the receiver.
_____3. More than 80% liquid in the receiver will cause	d. the pressure to increase in the receiver.
_____4. Using figure 2, compute the pressure for 96°F ambient temperature.	e. normal pressure.
	f. 106.5 psig.
	g. less pressure in the receiver.
	h. 110 psig.

Answers to Frame 18: 1. evaporator, condenser 2. cooling
3. the high side 4. removing heat

3091

TEMP° F	PSIG	TEMP° F	PSIG	TEMP° F	PSIG
0	9.2	54	51	108	132.4
2	10.2	56	53.1	110	136.4
4	11.3	58	55.4	112	140.5
6	12.4	60	57.7	114	144.7
8	13.5	62	60.1	116	150.0
10	14.7	64	62.5	118	153.2
12	15.9	66	65.0	120	157.7
14	17.1	68	67.6	122	162.1
16	18.4	70	70.1	124	166.7
18	19.7	72	72.9	126	171.4
20	21.1	74	75.6	128	176.1
22	22.5	76	78.4	130	181.0
24	23.9	78	81.2	132	185.9
26	25.4	80	84.1	134	191.0
28	27.0	82	87.1	136	196.1
30	28.5	84	90.2	138	201.3
32	30.1	86	93.3	140	206.6
34	31.7	88	96.5	142	212.0
36	33.4	90	99.8	144	217.5
38	35.2	92	103.1	146	223.1
40	37.0	94	106.5	148	228.9
42	38.8	96	110.0	150	234.0
44	40.7	98	113.5	152	240.5
46	42.7	100	117.1	154	246.5
48	44.7	102	120.9	156	252.6
50	46.7	104	124.6	158	258.8
52	48.8	106	128.5	160	265.1

Pressure and Temperature of Refrigerant 12.

Figure 2.

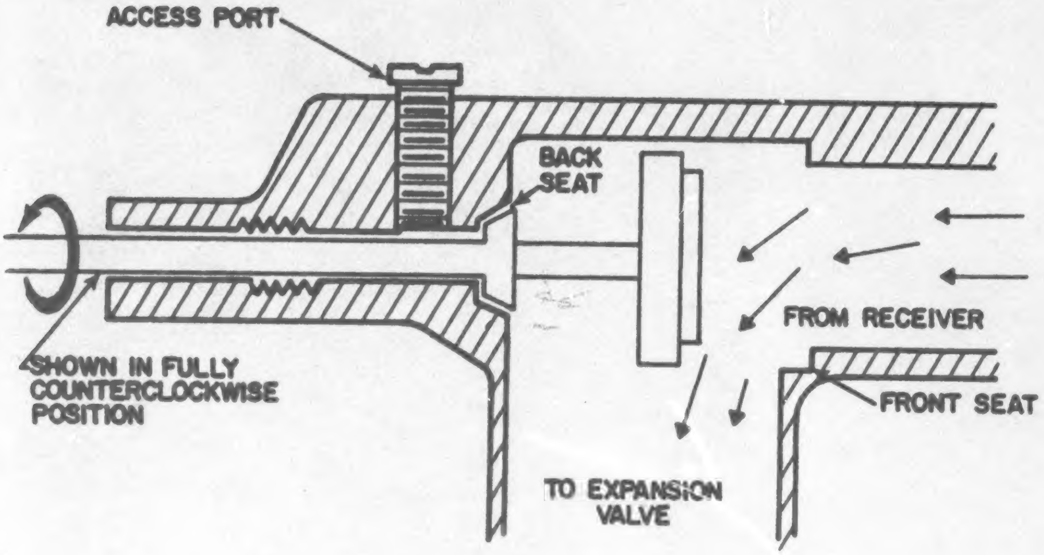

ACCESS PORT
BACK SEAT
SHOWN IN FULLY COUNTERCLOCKWISE POSITION
FROM RECEIVER
FRONT SEAT
TO EXPANSION VALVE

Figure 3.

3093

Frame 20

As with any tank, there must be an inlet and outlet. This has been provided on the refrigerant receiver. Manual valves are placed at both points. An inlet valve is put in between the condenser and the receiver. Generally this is mounted on the receiver itself. This valve is a common valve, just like a valve used with water, but may have a back seat position and an access port to the system. (See figure 3.) The back seat position (full counterclockwise) will close the access port so that gages may be put in to check the pressures in the system.

The outlet valve always has the back seat position to close the access port (charging port). This port is used for charging with a liquid (build up the amount of liquid refrigerant). A tube (dip tube) is hooked to the outlet valve and extends well below the liquid level of the receiver (see figure 1, item G). This makes sure that only liquid refrigerant gets into the liquid line. Both valves, when closed, will isolate the receiver from the remainder of the system (see figure 1, items G and H).

Fill in the blanks with the correct terms.

1. Manual valves are used to ______________ the receiver.

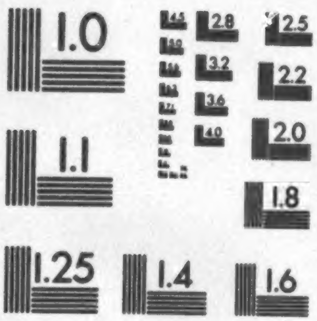
2. The access port on the receiver outlet valve provides a place to ______________ the system with liquid.

3. The back seat position of the valve ______________ the access port.

4. The tube (dip tube) attached to the receiver outlet valve insures ______________ ______________ ______________ enters the liquid line.

Answers to Frame 19: __b__ 1. __d__ 2. __d__ 3. __h__ 4.

2


1.0
2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS
STANDARD REFERENCE MATERIAL 1010a
(ANSI and ISO TEST CHART No. 2)

3094

Frame 21

The refrigeration system is under constant pressure with the high side having the highest pressure. A protective device is placed in the high side to prevent overpressurization of the system. The excessive pressure can cause leaks, resulting in loss of the refrigerant. One of the most common protective devices is the fusible plug (see figure 1). This is a threaded male plug that is placed in each end of the receiver. A lead alloy substance, placed in the center of the plug, will melt at a set temperature. If the pressure increases, temperature will also increase. When the melting point of the alloy is reached, the pressure that is in the tank will blow out the softened lead, relieving all pressure.

Complete the statements in column A by placing the letter from column B in the space provided.

Note: Some questions may require more than one response.

	Column A		Column B
____1.	The fusible plug protects	a.	the low side of the system.
____2.	Excessive system pressure can cause	b.	better cooling.
____3.	Leaks will result in	c.	the high side of the system.
____4.	When pressure in the system increases	d.	leaks at the soldered joint.
		e.	increased efficiency.
		f.	loss of refrigerant.
		g.	temperature decreases.
		h.	temperature increases.

Answers to Frame 20: 1. isolate 2. charge 3. isolates
4. only liquid refrigerant

Frame 22

While the refrigeration system is in operation, the high pressure liquid refrigerant flows through the liquid line on its way to the expansion valve. The expansion valve is most important to efficient system operation. For this reason, a filtering device is placed in the liquid line. This filter is referred to as the "dehydrator" (see figure 1, item I). It takes out moisture and foreign particles from the refrigerant. Moisture in the system can cause the following: sludge in the compressor, freezing at the expansion valve, and corrosion in the system. The drier part of the filter soaks up any moisture that may have been left in the system. The strainer, placed in the outlet end of the filter, takes out any foreign particles that may be in the refrigerant.

Complete the statements in column A by placing the letter from column B in the space provided.

Column A	Column B
_____1. If moisture enters the system it can cause	a. strainer.
	b. efficient operation.
_____2. Foreign particles are removed by the	c. moisture from entering the system.
_____3. Good maintenance practices can prevent	d. sludge.
_____4. The drier absorbs	e. drier.
	f. moisture.

Answers to Frame 21: __c__1. __d&f__2. __f__3. __h__4.

Frame 23

The refrigerant will pass by a "sight glass" after leaving the dehydrator. The sight glass is a port placed in the liquid line, with a glass insert that will let the mechanic visually check the condition of the refrigerant. Look at figure 1, item J, to find the sight glass. A normal sight glass indication is a completely clear glass. If bubbles are seen, it can mean a shortage of refrigerant or a restriction in the liquid line. If the refrigerant is discolored, it may mean that oil is circulating with the refrigerant. If discoloration is noted but disappears after a few minutes of operation, this would be considered normal. If the discoloration continues, a problem is indicated which will be explained in the troubleshooting section.

Complete the statements in column A by placing the letter from column B in the space provided.

	Column A		Column B
____1.	The sight glass is installed in the	a.	discoloration of the refrigerant.
____2.	A clear sight glass is an indication of	b.	bubbles in the sight glass.
____3.	A shortage of refrigerant will be indicated by	c.	an adequate refrigerant supply.
____4.	Oil circulating with the refrigerant may cause	d.	liquid line.
		e.	receiver.

Answers to Frame 22: d 1. a 2. c 3. f 4.

3097

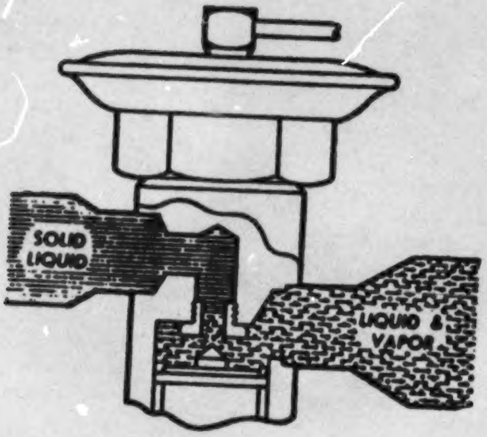

SOLID LIQUID
LIQUID & VAPOR

Figure 4.

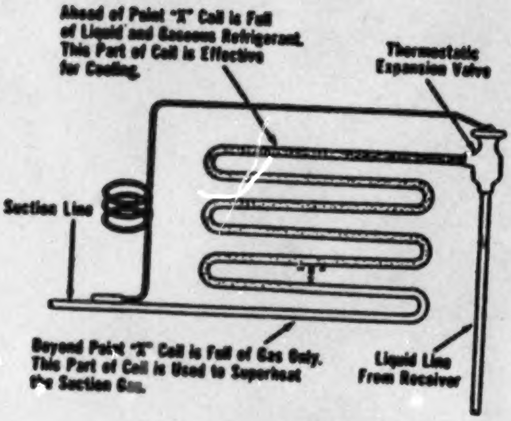

Ahead of Point "X" Coil is Full of Liquid and Gaseous Refrigerant. This Part of Coil is Effective for Cooling.
Thermostatic Expansion Valve
Suction Line
"X"
Beyond Point "X" Coil is Full of Gas Only. This Part of Coil is Used to Superheat the Suction Gas.
Liquid Line From Receiver

Figure 5.

484

After it goes through the sight glass, the liquid refrigerant goes in the expansion valve (look at figure 1, item M). The expansion valve is a metering device that lets the liquid refrigerant go in the cooling coil (evaporator) in the amount needed to cool the heat load. The liquid refrigerant goes in the expansion valve as a high pressure liquid and flows out as low pressure liquid. This is possible because the outlet and the connecting tubing are larger than the inlet. Look at figures 4 and 5 on the preceding page.

The cut in pressure will cause the refrigerant to boil at a low temperature in the evaporator. For example, the pressure keeping the refrigerant as a liquid at 90°F must be at 99.8 psig. If, after passing through the expansion valve, the pressure is cut down to 40 psig, the refrigerant will boil at a lower temperature (44°F). Look at figure 2 on page 30.

Complete the statements below by placing the missing words in the blanks.

1. After leaving the receiver, the liquid refrigerant enters the ____________ ____________ on its way to the ____________ ____________.

2. The expansion valve is a ____________ device.

3. An increase in heat load will cause the expansion valve to allow ____________ ____________ to enter the evaporator.

4. The refrigerant enters the expansion valve as a ____________ ____________ ____________.

5. With the pressure reduced to 35.2 psig, the boiling point of F-12 is ______°F. Refer to illustration 2 of HO-601.

6. The inlet to the expansion valve is ____________ than the outlet.

Answers to Frame 23: __d__1. __c__2. __b__3. __a__4.

3099

Frame 25

After it leaves the expansion valve, the refrigerant goes through the evaporator, where the real cooling takes place (see figure 1, item A).

An evaporator is a device (usually finned copper tubing when F-12 is used) in which the refrigerant is evaporated for the purpose of taking heat from the surrounding air.

As the refrigerant goes in the evaporator, it is a low pressure liquid. After it soaks up heat from the surrounding air through the walls of the evaporator, it changes from a low pressure liquid to a low pressure gas; so, on the inlet side of the evaporator, there is mostly liquid. As the refrigerant goes through the evaporator coils, more and more of the liquid is vaporized (boiled off) until at the outlet end, there is nothing but vapor. Look at figure 5 on page 36.

Complete the statements below by placing the correct terms in the space provided.

1. The refrigerant changes from a ______________ ______________ ______________ to a ______________ ______________ ______________ in the evaporator.

2. The refrigerant boils at a low temperature in the evaporator because ______________ is lowered.

3. Cooling the heat load actually takes place in the ______________.

4. The refrigerant leaves the evaporator as a ______________ ______________ ______________.

Answers to Frame 24: 1. liquid line, expansion line 2. metering
3. more refrigerant 4. high pressure liquid
5. 38°F 6. smaller

3100

Frame 26

The refrigerant leaves the evaporator and goes in the suction line as a low pressure gas (vapor). The suction line hooks the evaporator to the suction service valve on the compressor. The suction service valve provides a place to charge the refrigerant supply on the low side (gas). The valve has the same positions as the receiver outlet valve (forward and back seat position), see figure 3, page 31. The refrigerant now goes in the compressor (figure 1, item E) where it is set up for the condensing process. This takes in the raising of its pressure and temperature. Ambient air is used to take heat from the refrigerant so the compressor must raise the temperature of the refrigerant above ambient temperature. The refrigerant temperature that leaves the compressor will be approximately 30°F above ambient temperature. If for example, the ambient air is 80°F, the temperature of the refrigerant gas will be raised to approximately 110°F when it leaves the compressor. As the ambient air temperature increases, the temperature and pressure of the refrigerant that leaves the compressor also increases.

Complete the statements in column A by placing the letter from column B in the space provided.

Column A	Column B
_____1. Pressure leaving the compressor is determined by the	a. size of the receiver.
	b. receiver.
_____2. Changing the low pressure gas to high pressure gas is done by the	c. suction service valve.
	d. ambient air temperature.
_____3. The refrigerant leaving the evaporator must be	e. compressor.
	f. high pressure gas.
_____4. An increase in ambient air temperature will cause	g. compressor discharge pressure to remain constant
_____5. Charging with gas is done at the	h. compressor discharge pressure to increase.
	i. low pressure gas.

Answers to Frame 25: 1. low pressure liquid, low pressure gas
2. pressure 3. evaporator
4. low pressure gas

3101

Frame 27

The refrigerant now leaves the compressor through the compressor discharge valve. The valve is manual type and, when it is closed, it isolates the compressor from the high side. The high pressure refrigerant gas then goes in the discharge line and flows into the condenser, see figure 1, item B. The condenser is a coil of finned copper tubing similar in design to a car radiator. The heat picked up by the refrigerant in the evaporator, and the heat of compression are passed on to the air in the condenser. When the heat is taken from the hot high pressure refrigerant vapor, it will go back to its liquid state. Gravity now returns the liquid to the receiver where it is stored until it is needed by the expansion valve. This liquid will go in the receiver through the receiver inlet valve, look at figure 1, item H.

Complete the statements in column A by placing the letter from column B in the space provided.

Column A

_____ 1. The function of the condenser is to

_____ 2. The refrigerant entering the condenser is a

_____ 3. When heat is removed from the hot refrigerant gas

_____ 4. When the expansion valve meters refrigerant into the evaporator, it is a

Column B

a. low pressure gas.

b. it remains a gas.

c. change high pressure gas to a high pressure liquid.

d. high pressure gas.

e. it changes to liquid.

f. low pressure liquid.

Answers to Frame 26: d 1. e 2. i 3. h 4. c 5.

3/02

Frame 28

The basic system operation starts with the high pressure liquid refrigerant in the receiver. When the system is started, the liquid refrigerant flows to the expansion valve where its pressure is cut down. The refrigerant goes in the evaporator as a low pressure liquid where it boils at a low temperature and soaks up heat from the surrounding air. The refrigerant leaves the evaporator as a low pressure gas and flows to the compressor. The compressor gets the refrigerant ready for the condensing mode by raising its pressure and temperature. When it is compressed, the temperature of the refrigerant will be close to 30°F above the ambient temperature. The discharge pressure can be found with ease by using figure 2. For example, 70° ambient temperature plus the 30° from compression is 100°F. Looking at figure 2, we find a pressure of 117 psig would be the discharge pressure. To complete the cycle, the gaseous refrigerant must be returned to its liquid state. This is accomplished by the condenser where the hot refrigerant gas gives up its heat to the surrounding ambient air. The refrigerant returns by gravity to the receiver, where it is stored until needed by the expansion valve.

Complete the statements in column A by placing the letter from column B in the space provided.

Part I

Column A	Column B
A 1. The increase in refrigerant pressure is done by the	a. condenser.
	b. expansion valve.
____2. In the evaporator, the refrigerant changes from	c. compressor.
____3. When the ambient temperature is 90°F, and the unit operating, the discharge pressure will be	d. evaporator.
	e. liquid to gas.
	f. gas to liquid.
____4. The refrigerant absorbs heat in the	g. 157.7 psig.
____5. The refrigerant leaves the condenser as a	h. 136.4 psig.
	i. high pressure liquid.
	j. low pressure liquid.

3103

Frame 28 (Cont'd)

Match the component in column A to its function by placing the letter (preceding the correct function) from column B in the space provided.

Part II

Column A

_____1. Receiver

_____2. Receiver charging port

_____3. Drier-Strainer

_____4. Expansion valve

_____5. Evaporator

Column B

a. Permits charging on the low side.

b. Removes moisture and foreign particles.

c. Meters refrigerant into the condenser.

d. Meters refrigerant into the evaporator.

e. Permits charging on the high side.

f. Stores refrigerant.

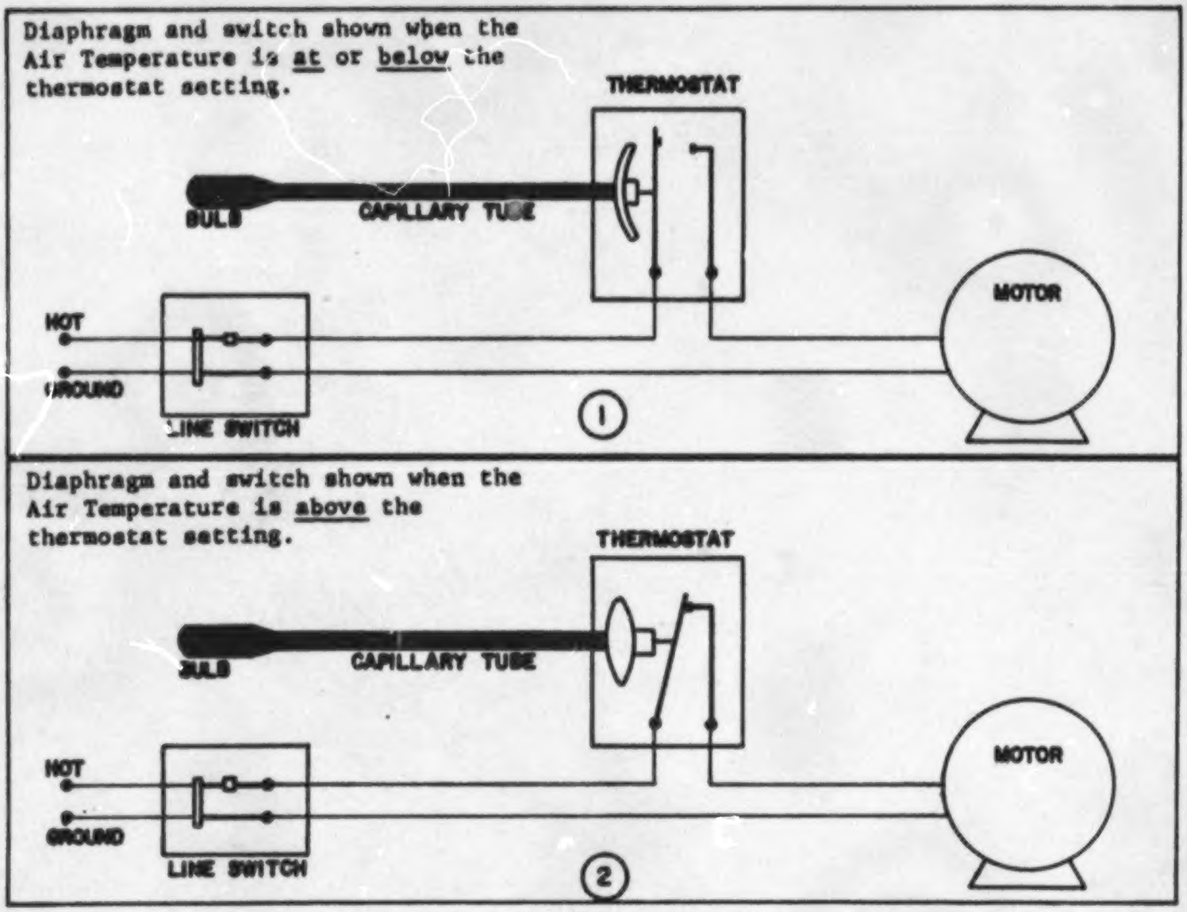
g. Where heat is removed from the air.

h. Where heat is given up to the air.

Answers to Frame 27: __c__1. __d__2. __e__3. __f__4.

490

3104



Diaphragm and switch shown when the Air Temperature is at or below the thermostat setting.

Diaphragm and switch shown when the Air Temperature is above the thermostat setting.

THERMOSTAT
BULB
CAPILLARY TUBE
MOTOR
HOT
GROUND
LINE SWITCH
①
THERMOSTAT
BULB
CAPILLARY TUBE
MOTOR
HOT
GROUND
LINE SWITCH
②

Figure 6.

3105

Frame 29

The temperature control unit (thermostat) works like the thermostat used in the home. It is built to open or close an electrical circuit in line with changes in temperature. The thermostats used are referred to as remote bulb thermostats. The remote bulb is placed in the zone where control of the temperature is needed. The bulb is filled with refrigerant and is hooked to a pressure operated switch by means of a capillary tube. When the temperature of the air rises above the thermostat setting, some of the refrigerant will boil and cause a pressure rise in the bulb and capillary tube. The pressure rise will close the electrical switch and start the system operating. (Look at figure 6, view 2, on the preceding page.) The system will continue to work until the air temperature drops to the thermostat setting. The reduced air temperature will cause some of the refrigerant to condense in the bulb. When the refrigerant in the bulb condenses, pressure will be reduced and the switch will open (look at figure 6, view 1) and stop system operation.

Complete the statements in column A by placing the letter from column B in the space provided.

Column A

_____1. To control the conditioned air temperature the remote bulb must be

_____2. A pressure increase in the bulb will

_____3. Air temperature changes

_____4. The refrigerant in the bulb will condense if

Column B

a. causes pressure to increase in the bulb.

b. causes pressure to change in the bulb.

c. start the system operating.

d. stop the system operation.

e. the air temperature drops.

f. the air temperature rises.

g. placed where control of the air temperature is needed.

Answers to Frame 28:

Part I — _c_ 1. _e_ 2. _g_ 3. _d_ 4. _i_ 5.

Part II — _f_ 1. _e_ 2. _b_ 3. _d_ 4. _g_ 5.

3/06

Frame 30

Match the response (component to function) from column B to the statement in column A by placing the letter preceding the response in the space provided.

Column A

____1. The basic refrigeration system consists of the

____2. Cooling of the heat load takes place in the

____3. The receiver is filled with

____4. The receiver outlet valve provides a place to

____5. The drier-strainer removes

____6. The sight glass is installed in the

____7. Liquid refrigerant is metered into the evaporator by the

____8. The change from low pressure liquid to low pressure gas occurs in the

____9. The low pressure gas enters the compressor through the

____10. The compressor changes

____11. The temperature control unit is referred to as a

Column B

a. suction line.

b. evaporator.

c. the low pressure cutout will stop the compressor.

d. expansion valve.

e. moisture from the liquid refrigerant.

f. thermostat.

g. liquid line.

h. 80% liquid and 20% gas.

i. low pressure gas to high.

j. high side of the system.

k. receiver, expansion valve, evaporator, compressor and condenser.

l. replenish the refrigerant on the high side.

m. high pressure gas to high pressure liquid.

Answers to Frame 29: __g__ 1. __c__ 2. __b__ 3. __e__ 4.

3/07

Answers to Frame 30:

Refer to the frame number listed in the right-hand column for additional information on items missed.

_k_ 1.	F-18
_j_ 2.	F-18
_h_ 3.	F-19
_l_ 4.	F-20
_e_ 5.	F-22
_g_ 6.	F-23
_d_ 7.	F-24
_b_ 8.	F-25
_a_ 9.	F-26
_i_ 10.	F-26
_f_ 11.	F-29

When you have completed frame 30 and reviewed the items missed, report to your instructor. You are now ready to take the test. When successfully completed, the instructor will assign your next project.

3/08

Frame 31

Because of the tubing and connections used in a refrigeration system, the possibilities of a leak of the refrigerant exists. Either of two methods can be uued to detect leaks.

The most widely used leak detector for refrigeration systems is the "halide torch." The torch consists of bottled gas, a chimney chamber with a glow plate, and a sampling tube. To use the torch as a leak detector, move the sampling tube slowly around the outside of any gasketed joint, seal, or fitting. At the same time, watch the flame for the slightest change in color. The color of the flame changes when a leak is found. A very faint color change indicates a small refrigerant leak. A very bright and vivid color change indicates a very large leak. The torch must be used in a well ventilated area. It only indicates that the leak is in the general area. It does not pin-point the leak.

The safest method for leak detection is the use of a soap and water solution. This method requires that you use a thick, almost pasty, mixture of soap and water. The solution is made up of 50% soap and 50% water. To make sure that the solution bubbles well, you can add a few drops of glycerine. Apply the mixture to the points where you suspect the leak to be. The leak will cause the solution to bubble and give you the exact location of the hole.

Place a checkmark (✓) in front of the correct statement(s) below.

_____1. When using the halide torch a very bright and vivid color change in the flame indicates a very large leak.

_____2. The safest method for leak detection is to use a soap and water solution.

_____3. When using a soap and water solution to detect leaks a very faint color change in the solution indicates a small leak.

_____4. The most widely used refrigeration leak detector is the halide leak detector.

Answers to Frame 31: __✓__1. __✓__2. _____3. __✓__4.

3!09

WORKBOOK
3ABR42331-WB-407

Technical Training

Aircraft Environmental Systems Mechanic

LIQUID REFRIGERANT SYSTEM MAINTENANCE

8 December 1978

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

3110

Environmental Pneudraulics Branch
Chanute AFB, Illinois

3ABR42331-WB-407

LIQUID REFRIGERANT SYSTEM MAINTENANCE

OBJECTIVES

1. Using an inspection workcard, maintenance data collection forms, and a trainer, inspect a liquid refrigeration system recording a minimum of two discrepancies. One instructor assist, per form, is permissible.

2. Using a trainer, perform an operational check of a liquid refrigerant system with one instructor assist.

3. Using a trainer and schematic, troubleshoot a liquid refrigerant system with one instructor assist.

4. Using a trainer and the necessary equipment, bench check and repair system components with one instructor assist.

EQUIPMENT

	Basis of Issue
Inspection Workcard	1/student
AFTO Form 349	8/student
Toolkit	1/student
Freon cylinder	1/student
Manifold gage assembly	1/student
H-10 leak detector	1/student
Leak Tec soap solution	1/student
Vacuum pump	1/student
Trainer 4369, liquid refrig	1/student

This workbook deals with inspecting, operating, and troubleshooting the refrigerant system. At strategic points throughout the procedures you will be required to have the instructor check your work and initial the workbook when the work is satisfactory. At the end of each section you will be required to have the instructor sign the completed workbook.

INSPECTION PROCEDURES

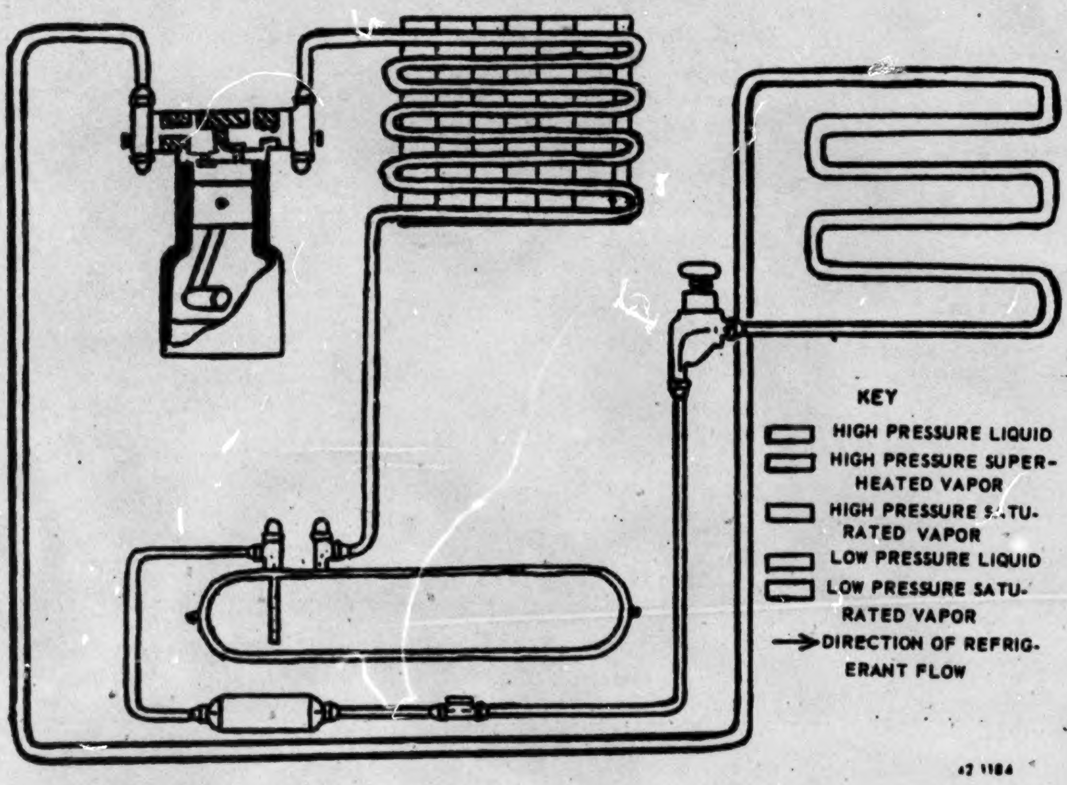
Using the AFTO Form 26 provided by your instructor as a guide, inspect each item listed thereon, recording a minimum of two discrepancies on the AFTO Form 349. One instructor assist is permissible on each discrepancy.

This supersedes 3ABR42331-WB-409, 15 November 1977.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 400; TTVSA - 1

OPERATING PROCEDURES

This workbook is to be used as the source for procedures to operate the air conditioner trainer. During operation, remember to observe the gages and indicators so you can determine the serviceability of the unit. The readings observed must be compared with the specifications found in table 1 to determine the exact status of the unit. Read at least one (1) step ahead throughout this workbook.

Refer to PT-409A to complete the following diagram. This is a basic refrigeration system.


KEY
HIGH PRESSURE LIQUID
HIGH PRESSURE SUPER-HEATED VAPOR
HIGH PRESSURE SATU-RATED VAPOR
LOW PRESSURE LIQUID
LOW PRESSURE SATU-RATED VAPOR
DIRECTION OF REFRIG-ERANT FLOW
47 1184

Color the system according to the key at the right of the diagram and also show direction flow.

Figure 1.

3112

REFRIGERATION SYSTEM

Before beginning the operational check, view the film Principles of Refrigeration.

OPERATIONAL CHECK

Note: Place your initials in the space provided when you complete each step in the workbook.

_____1. Obtain the manifold gage assembly and toolkit from the trainer cabinet.

_____2. Hang the manifold gage assembly on the back of the trainer.

_____3. Locate the "refrigeration system diagram" on the trainer.

_____4. Using a grease pencil, trace on the diagram to show how the manifold gage lines should be connected to the system components for reading system operating pressures. When you are complete, have your instructor check your work.

________ INSTRUCTOR'S INITIALS

_____5. Remove the two large caps from the discharge and suction service valves on the compressor. BACKSEAT BOTH VALVES SLOWLY BY TURNING THE STEMS COUNTERCLOCKWISE ALL THE WAY BACK. DO NOT OVERTIGHTEN.

_____6. Remove the two small caps from the discharge and suction ports on the compressor.

_____7. Connect the lines to the system components as you have drawn them on the system diagram, the low side on the manifold gage to the suction service port and the high side on the manifold gage to the discharge service port.

________ INSTRUCTOR'S INITIALS

_____8. Check the LOW and HIGH side valves on the manifold gage assembly to make sure they are in the closed (clockwise) position.

_____9. Take the ratchet wrench from the toolkit and position the suction and discharge service valves on the compressor to the "GAGE" position. (3 turns in)

________ INSTRUCTOR'S INITIALS

_____10. Put on goggles and purge the HIGH and LOW hoses by loosening the connections to the manifold assembly. When the hoses have been satisfactorily purged (one at a time) tighten the connections. Place a cloth around the connections to prevent Freon from spraying.

_____11. Both gages (high and low) on the manifold should indicate the same amount of pressure. NOTE: This is due to the compressor not operating. The pressure pushes out of the receiver and through the system. Read the pressure by looking at the black scale.

________ INSTRUCTOR'S INITIALS

____12. Record the temperature of the evaporator coils on Table 1 (space A).

____13. Connect the power cord to 110/115V AC wall outlet. The trainer power light should come "ON."

____14. Place the compressor switch to the "ON" position and notice the sight glass. The freon and oil will rise in the sight glass as they circulate through the system due to the compressor operating. Notice in the center of the sight glass there is a green dot. So long as this remains green, this indicates no moisture in the system. If the green turns to yellow, this means that the system has excessive moisture. The sight glass should be clear and full to the top.

________ INSTRUCTOR'S INITIALS

____15. Operate the unit for at least ten (10) minutes before recording any unit readings. After at least ten (10) minutes fill in the blanks in table 1. Take your readings from the high and low gages on the manifold gage assembly (BLACK SCALE). Compare the readings to the left column.

	Normal Reading	Unit Reading	SAT.	UNSAT.
DISCHARGE PRESSURE GAGE	90-130 psi	______	______	______
SUCTION PRESSURE GAGE	20-35 psi	______	______	______
SIGHT GLASS	clear	______	______	______
TEMPERATURE OF EVAPORATOR	a.____	b.____	c.____	

Table 1.

Note: The reading obtained from your manifold gage assembly will vary in psi due to ambient temperature around the evaporator.

____16. Record the temperature of the evaporator coils on table 1 (space "b"). The temperature drop will be placed in space "c."

SHUTDOWN PROCEDURES

____1. Place the compressor switch to the "OFF" position.

____2. Unplug the power cord from the wall receptacle.

TROUBLESHOOTING PROCEDURES

1. If an "UNSATISFACTORY" condition was noted, record in the space provided.

a. TROUBLE ____

____

____

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b. Refer to table 2 and record the probable cause(s) in the space provided.

____

____

____

c. Analyze all probable causes carefully. You will be able to eliminate each listed cause as indicated in the "REMEDY" column as you go through this workbook. Then when you have completed the final operational check, you can reverify the system's condition to see if you eliminated the problem.

TROUBLE	PROBABLE CAUSE	REMEDY
Bubbles appear in sight glass	Shortage of freon (system pressure will also be low)	Compare suction pressure to TP chart. Service system.
	Moisture	Check moisture indicator in sight glass. If yellow, evacuate the system.
	Clogged drier strainer	R&R drier strainer
Low suction pressure	Superheat adjusted too high	Adjust expansion valve (ccw)
	Shortage of freon	Service system
	Dirty air filter	Purge and evacuate system
	Oil clogged evaporator	Purge and evacuate system
	Low load	R&R drier strainer
High discharge pressure	Air in the system	Evacuate and reservice system
	Overcharge of freon	Partially drain and reservice
	Receiver inlet valve not fully open	Open valve fully
High suction pressure	Oversized expansion valve	Replace expansion valve
	Expansion valve seat leak	Replace expansion valve
	Low superheat adjustment	Adjust expansion valve (cw)

DRAINING SYSTEM PRESSURE

SAFETY: Put on goggles (located in trainer cabinet) for steps one through five.

REMOVAL

_____ 1. Backseat the compressor's discharge valve by backing it out. Leave the suction valve in the "GAGE" position.

CAUTION: DO NOT OVERTIGHTEN THE VALVE(S) WHEN YOU ARE FRONT SEATING OR BACK SEATING THEM.

_____ 2. Obtain the drain can from the trainer cabinet.

_____ 3. Connect one end of the line to the manifold gage assembly service port (see trainer diagram). Place the other end of the hose into the drain can.

_____ 4. Open the high valve on the manifold assembly to bleed the pressure out of the line which connects to the compressor's discharge port. Then close after the pressure escapes completely.

_____ 5. Crack open (counterclockwise) slowly (little by little) the low valve on the manifold gage assembly until all the pressure has escaped and the low pressure gage reads "0." NOTE: THE REASON TO DO THIS IS THAT THE HIGH SIDE CONTAINS THE RECEIVER WHICH HOLDS THE FREON, AND SOME, IF NOT MOST, OF THE OIL. THE REST OF THE OIL IS EITHER IN THE SYSTEM LINES OR IN THE COMPRESSOR. SO REMEMBER, THE SLOWER THE PRESSURE COMES OUT, THE LESS OR NO OIL THAT WILL COME OUT OF THE SYSTEM. THEN YOU WILL NOT HAVE TO SERVICE THE COMPRESSOR OR SYSTEM WITH OIL. HAVE THE INSTRUCTOR CHECK THIS STEP WHILE YOU DO IT.

_________ INSTRUCTOR'S INITIALS

EVACUATE THE SYSTEM

Before beginning to evacuate the system, view film Evacuating and Servicing.

VACUUM TEST PROCEDURES

The vacuum test will be performed three times.

_____ Vacuum Test #1 (Do steps 1, 2, 3, 4, 5, 6, 6a, 7, 8, 9).

_____ Vacuum Test #2 (Do steps 4, 5, 6, 6a, 7, 8, 9).

_____ Vacuum Test #3 (Do steps 4, 5, 6, 6a, 7, 8, 9).

_____ 1. Obtain the vacuum pump location from the lab instructor.

_____ 2. Using a grease pencil, trace on the diagram to show how the manifold gage lines should be connected to the system components for reading system vacuum pressure. When complete, have the lab instructor check your work.

________ INSTRUCTOR'S INITIALS (TEST #1)

_____3. Connect the manifold assembly using the lines going to the system components as you have shown them on your diagram.

________ INSTRUCTOR'S INITIALS (TEST #1)

________ INSTRUCTOR'S INITIALS (TEST #2)

________ INSTRUCTOR'S INITIALS (TEST #3)

_____4. Ensure that the discharge valve is back seated and suction valve is in the GAGE" position. (3 turns in)

________ INSTRUCTOR'S INITIALS

_____5. Plug in the vacuum pump to a 110/115V AC wall outlet. NOTE: VACUUM PUMP WILL OPERATE AS SOON AS THE CORD IS CONNECTED TO THE WALL OUTLET.

_____6. Open the low valve on the manifold assembly. NOTE: REMEMBER TO OPEN IT SLOWLY SO THAT YOU WILL NOT THROW ANY OIL OUT OF THE SYSTEM. THE PRESSURE IS ESCAPING AND GOING THROUGH THE VACUUM PUMP AND INTO THE DRAIN CAN.

________ INSTRUCTOR'S INITIALS

_____6a. When you have obtained a vacuum of 28" Hg, crack open the high valve so that all the pressure can escape completely. This lets the pressure out of the manifold gage. (LOW GAGE GREEN SCALE is vacuum).

_____7. Operate the pump five minutes more after obtaining a reading of 28" Hg (vacuum is the low gage Green Scale).

________ INSTRUCTOR'S INITIALS

_____8. Close the low valve on the manifold assembly and unplug the vacuum pump. This will stop the air from entering the system when you disconnect the vacuum line.

_____9. Disconnect the service line from the vacuum pump. Set aside the pump on a bench so that it will be out of your way.

NOTE: AFTER THE FIRST VACUUM TEST, PERFORM THE PURGING PROCEDURES, THEN PERFORM THE SECOND VACUUM TEST AND PURGE THE SYSTEM AGAIN. AFTER THE SECOND PURGE, PERFORM THE THIRD VACUUM TEST THEN CONTINUE TO THE SERVICING PROCEDURES.

PURGING THE SYSTEM

_____1. Obtain the location of the R-12 refrigerant from the instructor.

_____2. Place the refrigerant (R-12) container on the trainer.

NOTE: PURGING IS TO REMOVE ANY CONTAMINANTS THAT MIGHT BE IN THE SYSTEM (SUCH AS MOISTURE, DUST, DIRT, ETC). EVEN THOUGH THIS IS WHAT THE DRIER STRAINER IS USED FOR, IT CAN SAVE THE REMOVAL AND REPLACEMENT OF THE DRIER AT SUCH AN EARLY TIME.

_____3. Using a grease pencil, trace on the diagram to show how the manifold assembly lines should be connected to the system components for purging.

________ INSTRUCTOR'S INITIALS

_____4. Connect the lines to the trainer components as you have drawn them on the diagram.

________ INSTRUCTOR'S INITIALS

SAFETY: PUT ON GOGGLES FOR STEP NOs 5 and 6.

_____5. Open the refrigerant service valve on the container. NOTE: THIS ALLOWS GASEOUS R-12 REFRIGERANT TO YOUR MANIFOLD ASSEMBLY.

_____6. Purge the service hose by loosening slightly the connection to the manifold assembly. This will allow the air to be pushed out and the freon to take its place. Then tighten the connection when you have satisfactorily purged the hose. If you do not purge the hoses correctly the vacuum and purging will have to be done again.

CAUTION: FREON IS COLD, SO PLACE A CLOTH AROUND THE CONNECTION TO PROTECT YOURSELF.

_____7. Plug in the trainer power to a 110/115V AC wall outlet. Trainer power light should come "ON."

_____8. Open the high valve on the manifold assembly. Both gages should indicate the same amount of pressure. NOTE: IMMEDIATELY DO STEP 8 and PAY CLOSE ATTENTION TO STEP Nos 9, 10, and 11.

_____9. Place the compressor switch to the "ON" position.

____10. Operate the system for thirty seconds. Then close the high valve on the manifold assembly.

____11. Turn the compressor switch "OFF" and unplug the trainer.

____12. Close the service valve on the freon container.

____13. Put on your safety goggles and crack open the line at connection to the freon container and let the pressure escape slowly. NOTE: IF THE GAGES ON THE MANIFOLD ASSEMBLY DECREASE IN PRESSURE ON THE BLACK SCALE, THIS MEANS THE HIGH AND LOW VALVES ARE NOT CLOSED ALL THE WAY ON THE MANIFOLD ASSEMBLY.

CAUTION: FREON IS COLD, SO PLACE A CLOTH AROUND THE CONNECTION TO PROTECT YOURSELF.

____14. Slowly disconnect the service line at connection to the freon container the rest of the way, making sure that the pressure has escaped.

____15. Cap open connection on freon container and set it aside.

____16. PERFORM VACUUM TEST AFTER THE FIRST AND SECOND PURGE. AFTER THE THIRD VACUUM, PERFORM THE SERVICING PROCEDURES.

SERVICING

_____1. Place refrigerant (R-12) container on trainer.

_____2. Using a grease pencil, trace on diagram to show how the manifold gage lines should be connected to the system components for servicing.

________ INSTRUCTOR'S INITIALS

_____3. Connect the lines on the trainer as you have drawn them on the diagram.

________ INSTRUCTOR'S INITIALS

________ SAFETY: PUT ON GOGGLES FOR STEP 4.

_____4. Open the service valve on the freon container. Leave the container upright so that you service the system with gas. Purge the service hose.

_____5. Plug in the trainer to a 110/115V AC wall outlet.

_____6. Open the low valve on the manifold gage assembly. Both gages should indicate pressure.

_____7. Place the trainer switch to the "ON" position and operate the system until the discharge pressure gage indicates about 100 psig.

_____8. Now, carefully watch sight glass on trainer. When the sight glass is HALF (1/2) FULL OF FREON liquid, notify the lab instructor. When the sight glass is 3/4 full, close the service valve on the freon container and this will possibly allow the gas or liquid freon in the lines to top off the sight glass and the system.

________ INSTRUCTOR'S INITIALS

____9. Leave the system connected as is and operate for ten more minutes. Then take the following readings:

________ SIGHT GLASS ________ SUCTION GAGE ________ DISCHARGE GAGE

____10. Now compare the above readings with table 1.

____11. Is the unit operating correctly?

________ UNSAT. ________ SAT.

________ INSTRUCTOR'S INITIALS

____12. Close the low valve on the manifold assembly.

____13. BACKSEAT the suction and discharge service valves on the compressor. NOTE: REMEMBER, DO NOT OVERTORQUE. NOTIFY THE INSTRUCTOR TO CHECK THE POSITION OF THE VALVES.

________ INSTRUCTOR'S INITIALS

________ SAFETY: PUT ON GOGGLES FOR STEP NOs 14 - 18.

____14. Disconnect the service hose from the freon container. CAUTION: USE A CLOTH AROUND THE CONNECTION.

____15. Place the service hose in the drain can.

____16. Open slowly the low valve on the manifold assembly so that all the pressure can escape. NOTE: LEAVE THE VALVE OPEN DUE TO THE LIQUID FREON THAT WILL BE IN THE LINE.

____17. Repeat step 16 for the high side.

____18. Disconnect the high and low side hoses from the compressor. Cap the open ports. Torque caps to 90 inch lbs.

____19. Connect the hoses as on figure 2 and close the high and low valves on the manifold assembly.

____20. Place the manifold assembly and drain can in the trainer cabinets properly.

____21. Turn the suction and discharge service valves a HALF (1/2) TURN IN. (TO THE "GAGE" POSITION)

NOTE: THIS WILL KEEP THE SERVICE VALVES FROM FREEZING IN THE BACKSEATED POSITION.

________ INSTRUCTOR'S INITIALS

____22. Cap the service valves.

____23. Turn off the compressor switch.

NOTE: NOW YOU ARE READY TO PERFORM THE LEAK TEST.

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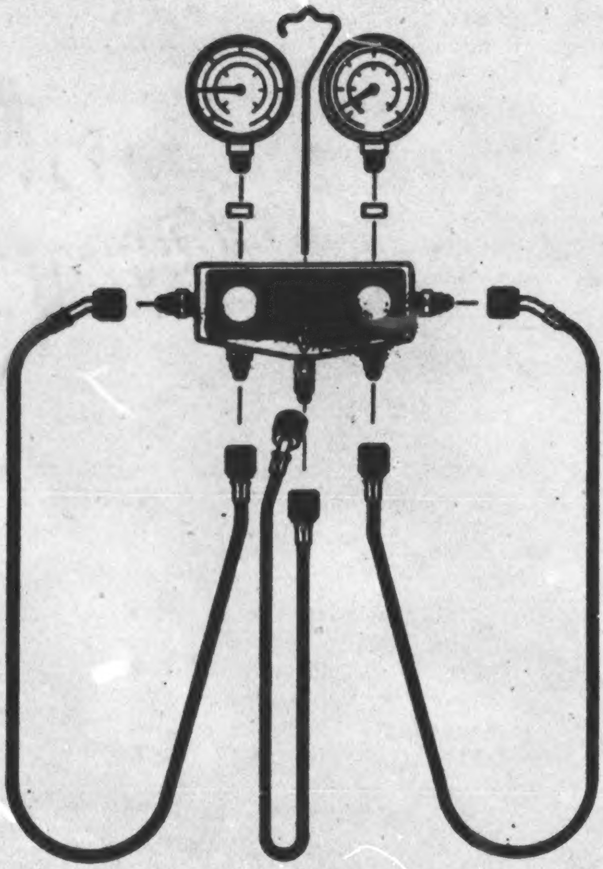

Figure 2.

LEAK TEST

Before beginning the leak test, view film Thermostatic Expansion Valve.

USING THE SOAP SOLUTION

_____1. Obtain the location of the "Leak Tec" solution from the instructor.

_____2. Shake the bottle until you have enough bubbles to apply to each tubing connection which might have a possible leak. Apply the solution and look for leaks. Remove the Leak Tec solution (using a cloth) from the area in which you applied it after verifying that there are no leaks.

_____3. Troubleshot and found the following leaks:

____

____

____

_____14. Have the instructor check your work. DO NOT TIGHTEN THE LEAKING CONNECTIONS AT THIS TIME, because you will verify the system using the H-10 leak detector.

_________ INSTRUCTOR'S INITIALS

_____5. Place the "Leak Tec" solution back where you found it.

_____6. Now perform another leak test using the H-10 leak detector.

LEAK TEST USING THE H-10 LEAK DETECTOR

_____1. Obtain the leak detector from your lab instructor.

_____2. Plug in the power cord of the leak detector into the trainer outlet which is located next to the temperature control box.

_____3. The leak detector will start to warm up immediately after the power cord is plugged into a 110/115V AC outlet.

_____4. Check for sufficient airflow by pointing the probe tip toward the floor and observing the airflow ball (in the probe). The height the ball rises is not important as long as it rises. If the airflow ball DOES NOT RISE, tap the probe lightly to make sure the ball isn't sticking. If the ball does not rise at all, inform your instructor.

_____5. Place the "Sensitivity" switch in either the HIGH or LOW positions.

NOTE: THE "LOW" RANGE POSITION IS USED TO DETECT LARGE LEAKS AND IS USED WHEN THE SENSING ELEMENTS OF THE TESTER ARE NEW. THE "HIGH" RANGE POSITION IS USED TO DETECT SMALL LEAKS.

CAUTION: IN A HIGHLY CONTAMINATED AREA, THE FLASH RATE WILL NOT BE STABLE AND IT WILL BE ALMOST IMPOSSIBLE TO "BALANCE" THE DETECTOR. UNDER THESE CONDITIONS, LEAK CHECKING WOULD NOT BE POSSIBLE.

_____6. Adjust the flash rate of the neon lamp in the probe by rotating (clockwise-or-counterclockwise) the "balance" control so that the neon lamp just ceases to flash. If adjusted properly, the light WILL FLASH and continue to flash when the probe is held at the "Reference Leak." When the probe is removed from the "Reference Leak," the flashing rate will slow down and STOP.

_________ INSTRUCTOR'S INITIALS

_____7. The "Reference Leak" may be used as often as necessary to assure proper operation of the leak detector, or as a comparing means to assist you in determining the size of the leak. (R-11 is used in the H-10 detector for adjusting the reference leak by setting the flash rate of the probe.)

_____8. Hold the probe as closely as possible to the area being tested and move the tip at ONE INCH PER SECOND (or less) along the seams or joints suspected of leaking. When the probe encounters a leak, the flashing rate of the neon lamp will increase and will continue to flash at the faster rate as long as the probe is held at the leak.

_____9. Troubleshot and found the following leaks:

____

____

____

_____10. Have instructor check your work. If there are any leaks, the instructor will advise you what to do.

________ INSTRUCTOR'S INITIALS

_____11. Unplug the trainer and the tester. Place the tester back where you found it.

_____12. Notify the instructor of your completion.